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Mandibular Movements—*Kurth*

Cystic Tumors of Neck—*McNealy*

Glandular Factors in Decay—*Hardgrove*

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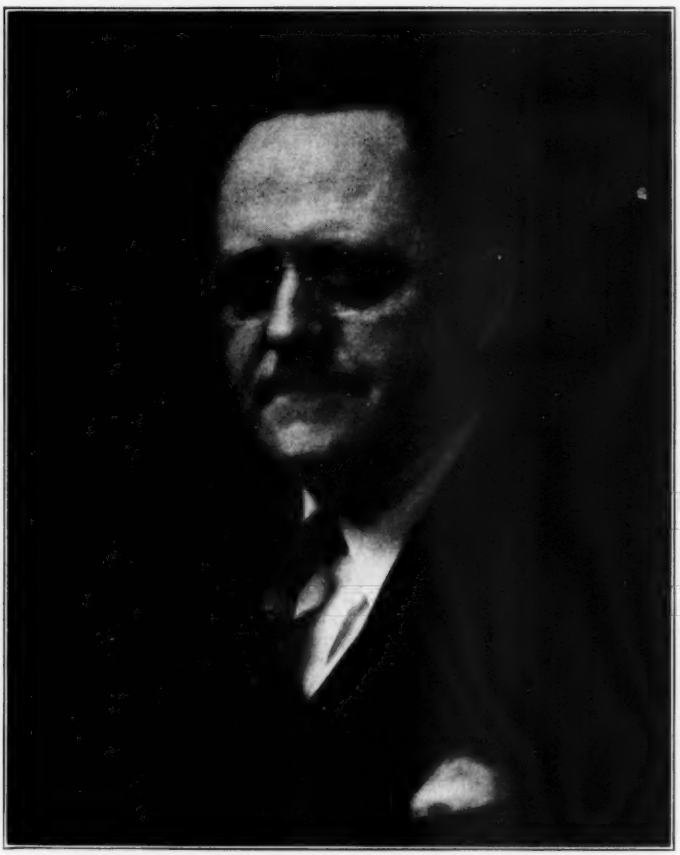

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MANDIBULAR MOVEMENTS IN MASTICATION*

By L. E. KURTH, D.D.S., Chicago, Ill.

INTRODUCTION

MANDIBULAR movement has been a source of investigation by dentists from the time of the discovery of the relationship between this movement and the actual functioning of dental restorations. Many of the studies on mandibular movement of the past have been incomplete or so shrouded with a complicated geometric formula or articulator technic that their meaning has been obscured. It will be the aim of this paper to present clearly by means of graphic tracings and stroboscopic pictures the entire phenomenon of the direction of mandibular movement in three dimensions of space in its relation to the physiologic act of mastication.

The masticatory apparatus of man is the result of ages of evolutionary progress,[1] with change of form always following change of function. Thus, the mandible, the temporomandibular joint and the teeth of the carnivora, herbivora and omnivora are different from one another because they are used for different purposes. The prime movement in the carnivora is "in a vertical rotary manner around the axis of the condyle as center"[2]; that is, an opening and closing movement. "The functional direction (of the herbivora) is preponderantly horizontal,"[3] or a wide range of lateral movement. The mandibular movement of the rodent is essentially anterior and posterior in direction.

Man, belonging to the omnivora, has a mandible, temporomandibular joint and teeth that combine all these characteristics of his evolutionary predecessors. It is to be regretted, however, that the early investigators broke down the cycle of mandibular movement into its various components as exemplified by the animal groups, and made an individual study of each, rather than depicting the end-result or a masticatory stroke which is a fusion of these various muscular efforts.

The location of the axis of the opening movement of the mandible, for instance, has created quite a controversy since its discovery as an entity of mandibular movement. William E. Walker,[4] one of the first scientific investigators of

*Chicago Dental Society Essay Award, 1942.

this subject, placed the opening axis of the mandible at a point five-eighths inch below and back of the condyle cord. The condyle cord is the base of Bonwill's triangle,[5] or the line connecting the center of the head of the right condyle with that of the left. Chissin[6] asserted that a rotation and a translatory movement combined to make the opening movement. Gysi[7] concurred in these findings, but placed the opening axis on a point three-quarters inch below and back of the condyles. Snow and Hanau placed the opening axis of their articulators on the condyle cord, where it was also later placed by Gysi in his trubyte articulator. Rupert E. Hall[8] says, "Gysi has returned to the condyle cord as the axis for the opening movement in the trubyte articulator, abandoning the more anatomic

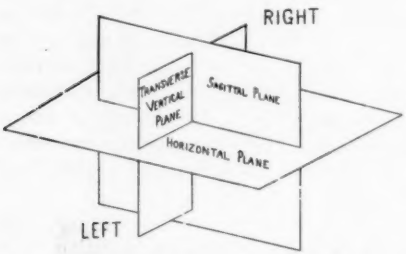

Fig. 1.—Diagram illustrating three dimensions of space to which direction of mandibular movement should be referred.

point (back of and below the condyles) previously employed in the adaptable and simplex articulators and to which he is altogether too well committed in the past to drop without criticism." Thus, we have the paradox of two schools of thought in relation to the opening axis: those who believe it is on the condyle cord as opposed to those who believe it is somewhere else.

The same situation prevails to a greater or less degree with the various other components of mastication. Some believe that there is a wide lateral range of movement, while others believe that it is limited. It seems, however, that an attempted analysis of mandibular movement by the consideration of a component alone rather than a functional stroke of mastication is a fallacious one. The chemist can readily demonstrate this fact by citing the physical properties of hydrogen, sulfur and oxygen, all of which are lost when the three elements unite to form sulfuric acid, which has properties different from those of its components. We, as dentists, can and should be cognizant of the various properties of the components of mandibular movement, but we should not let this knowledge cloud our minds to the more essential fact that these entities are lost when they become fused together to form the movement of mastication in which we are primarily interested.

HISTORY

There is an enormous volume of literature on the study of mandibular movement. Hildebrand[9] gives a bibliography mainly of foreign writers, and studies by Hall,[10] Schlosser[11] and Swenson[12] offer an excellent bibliography of American investigators. A review of these articles revealed that none of them utilized or explained the direction of the movement of the mandible in three dimensions at three points, and most of them did not distinguish between a masticatory stroke and a mandibular glide.

Mastication can be divided into three distinct acts: (1) the incision, (2) the chewing and (3) the swallowing of the food. Here, we are concerned with the mandibular movement that occurs during the chewing cycle, which can be further subdivided into a glide and an actual stroke of mastication.

It is an error to assume that because patients can make extreme movements to the right, left or forward in a glide, these are the normal movements in mastication. However, this ability does

show the versatility of the temporomandibular joint and the fact that the patient is able to follow the instructions given by the dentist. The difference between these subdivisions will be shown in this study.

It is axiomatic in the study of physics that, to chart the movement of a solid in space at least three points of observation are necessary and all movement should be referred to the three dimensions at each point. Hildebrand, for instance, made his observations at the

Fig. 2.—Transverse vertical view of specially designed facebow. Tracings can be taken of the mandibular movement in the three dimensions at the right and left condyles and the incisor point.

contact point of the two lower central incisors, which is called the incisor point or the apex of Bonwill's triangle, but referred this movement to only the two dimensions, as the transverse vertical and sagittal. This, of course, gives only two-thirds of the entire picture of what is happening at this one point, especially when it is considered that we do not use these two dimensions in the practical application of this problem to dentistry, where the movement of the incisor point in the horizontal plane is the most important one.

Previous studies utilized various methods, from direct observation to the graphic or photographic method, all of which have advantages and disadvantages. The graphic method for tracing mandibular movement is employed in this study because this method is used clinically in dentistry. Stroboscopic

Fig. 3.—Sagittal view of specially designed facebow. The three planes can be readily seen in the condylar region, and the method for obtaining the three dimensional tracings at the incisor point is easily discernible.

photographs were also utilized to verify the movement of the incisor point.

The anatomy of this area has been fully presented in an excellent article by H. J. Prentiss.[13]

EXPLANATION OF THE GRAPHIC METHOD OF INVESTIGATION

In consideration of a plan to study

mandibular movement further, it was decided that three points on the mandible would have to be charted. The points selected were the right and the left condyle and the incisor point. A facebow was devised so that tracings of mandibular movement could be made at these three points in three dimensions, which are here identified as the transverse vertical, horizontal and sagittal planes. (Fig. 1.) Various other names etc. This facebow was constructed of materials light in weight and yet rigid. (Figs. 2 and 3.) Tubings to hold the styluses were attached to the mandibular section of the facebow, except in the horizontal plane at the incisor point, where the stylus was attached to the maxillary bow. Receptacles were made and attached to the facebow to hold glass plates which were cut to fit them. These glass plates were lightly coated with wax

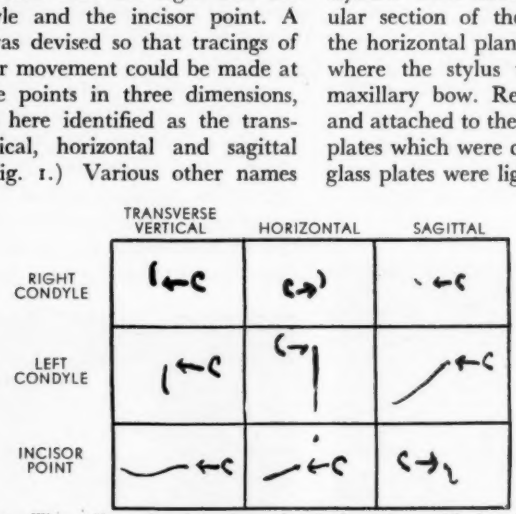

Fig. 4.—Three dimensional tracings of right lateral mandibular glide of patient A.

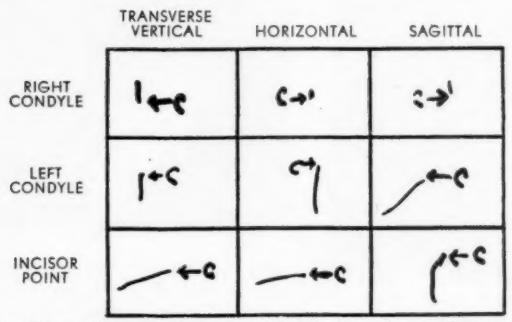

Fig. 5.—Three dimensional tracings of right lateral mandibular glide of patient B.

can be given to these three dimensions: to the transverse vertical, the frontal plane; to the horizontal, the occlusal or top plane, and to the sagittal, the side or medial plane. These other names having been used mainly with reference to the incisor point, the terminology presented above is used to prevent confusion in interpretation at the condyles, where there could be no occlusal plane, upon which a tracing could be made.

Accurate impressions of both maxillae and mandible of the patients utilized in this study were obtained in hydrocolloid. Casts were made from these impressions and mounted in centric relation on an articulator. Acrylic appliances that would not interfere with the articulation of the teeth were constructed. Provision was made in the region of the central incisors

on the maxillary and mandibular acrylic appliances for the attachment by cement and screws of the individual parts of the facebow. Care was taken to keep the arms of the facebow parallel to one another and both parallel to the horizontal plane of the face. The appliances were rigidly cemented in place in the patient's mouth by means of zinc oxide-eugenol paste. The various styluses were placed directly over those areas where a tracing was desired. The most difficult stylus to place is the one that traces the condyle path, which must be at the center of the condyle head. The waxed plates were then inserted in the respective receptacles on the facebow. The patient was instructed to make the desired mandibular movement, which resulted in the tracing of a line through the wax by the styluses, showing the direction of this movement from centric relation. The glass plates were carefully removed after a tracing was made, and the lines through the wax were etched in the glass by means of hydrofluoric acid, thus making a permanent record of the tracing.

SUBJECTS UTILIZED IN THIS STUDY

Three male and two female adult subjects were used in this investigation. Patient A (female) had a normal occlusion with a complement of twenty-nine teeth. The two upper third molars and the lower left third molar were missing. There was an overbite of 1 mm. in the region of the central incisors.

Patient B (male) had twenty-nine teeth, with the lower right first molar and the lower left second bicuspid and

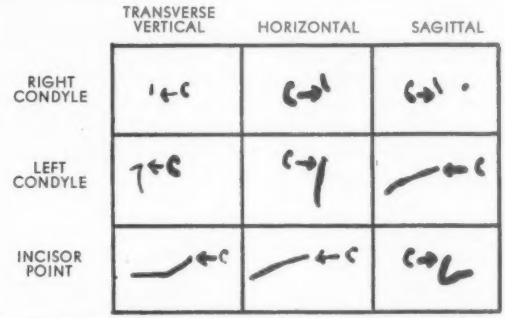

Fig. 6.—Three dimensional tracings of right lateral mandibular glide of patient C.

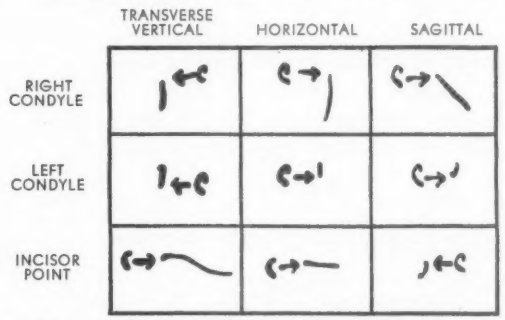

Fig. 7.—Three dimensional tracings of left lateral mandibular glide of patient A.

first molar missing. The occlusal relationship, except for the missing teeth, could be considered normal. The overbite was 3 mm. in the region of the central incisors.

Patient C (female) had twenty-eight teeth in perfect occlusion, with all third molars missing. The overbite in the region of the central incisors was 2 mm.

Patient D (male) was edentulous.

Patient E (male) had a crossbite occlusion with a complement of twenty-eight teeth. There was an overbite of 3 mm. in the region of the central incisors.

Patient E was used to obtain the stroboscopic pictures of the movement of the incisor point.

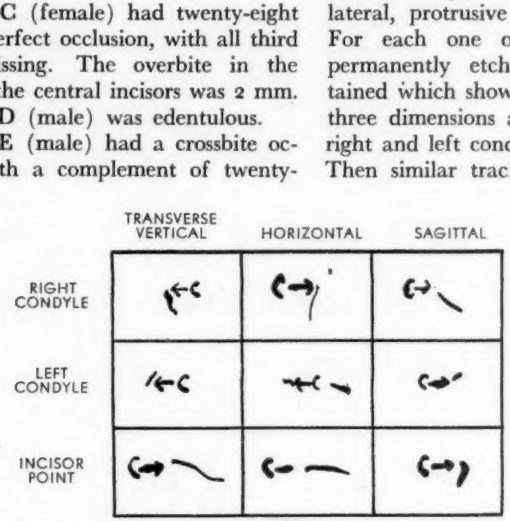

Fig. 8.—Three dimensional tracings of left lateral mandibular glide of patient B.

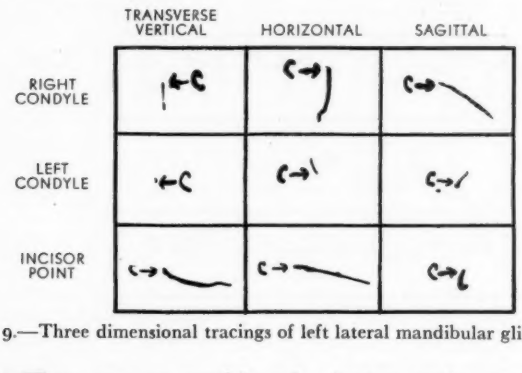

Fig. 9.—Three dimensional tracings of left lateral mandibular glide of patient C.

PLAN OF PROCEDURE

The first experiments were directed toward graphing the movements of the mandible in an unrestricted glide to the extreme limits of tooth and condylar guidance. The glide was divided into its various components as right lateral, left lateral, protrusive and simple opening. For each one of these components, permanently etched glasses were obtained which showed their movement in three dimensions at the location of the right and left condyle and incisor point. Then similar tracings of a single masticatory stroke were obtained, followed by one demonstrating multiple strokes of mastication.

These glasses were photographed after being carefully placed for this purpose without interfering with the relationship of the tracing to the horizontal and vertical planes. These photographs are arranged so that each one of the com-

ponents for each patient can be observed. Tracings for the opening or masticatory movements of patient D, who was edentulous, could not be made because the weight of the facebow was enough to cause a slight dislocation of the denture bases on the ridges, which would result in an unreliable tracing. The tracings of a masticatory stroke on the horizontal plane at the incisor point was so entirely different from what was expected that stroboscopic pictures were taken of patient E for verification.

It will be shown that the directions of mandibular movement were virtually the same for the subjects studied, although the angle and the extent of movement varied. Consequently, the general direction of movement will be explained, and

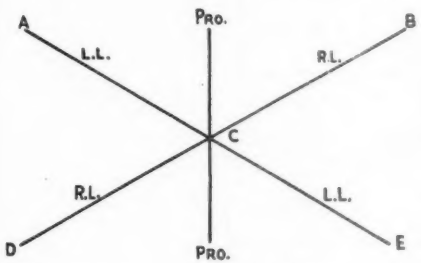

Fig. 10.—Diagram demonstrating two gothic arches that can be traced on horizontal plane at incisor point. Gothic arch DCE is traced when the stylus is on the maxilla and the tracing plate on the mandible. Gothic arch ACD is traced when the positions of the stylus and the tracing plate are reversed.

the exceptions noted by reference to the various tracings. A discussion of the results will follow this explanation.

THE COMPONENTS OF MASTICATION

Right Lateral Mandibular Glide.—The tracings demonstrated that when patients A, B and C (Figs. 4, 5 and 6) made a right lateral glide, the right condyle had a limited movement upward and to the right in the transverse vertical plane, while both the left condyle and the incisor point moved downward in a much longer stroke to the right in the same plane. The movement of the right condyle in the horizontal plane was limited, backward and to the right, while the left condyle and incisor point moved forward to the right. This movement of the condyle head in the horizontal plane has been called the Bennett[14] movement in honor of its discoverer. The right condyle moved upward and backward from centric relation in the sagittal plane, while the left condyle moved downward and forward. The movement in this plane at the incisor point varied: For patient A, the tracing was downward and forward; B described a backward and downward movement; while with C, the movement was downward and backward, then upward and forward.

A careful analysis of these directions demonstrates that it is impossible for one pivotal point to be the center of this movement. The right condyle would remain fixed in the glenoid fossa, and the left condyle and the incisor point would move in the same direction if this movement had one definite center. This, however, is not true, an entire area with a shifting center near the head of the condyle being responsible for this movement.

Left Lateral Mandibular Glide.—The movement of these three points for patients A, B and C (Figs. 7, 8 and 9) in a left lateral glide is the reverse of that in the right lateral glide. The right condyle described a long movement downward to the left in the transverse vertical plane; the left condyle had a limited movement upward and to the left, and the incisor point moved downward to the left. The right condyle moved forward to the left, the left condyle moved backward to the left and the incisor point moved forward to the left, in the horizontal plane. The right condyle in the sagittal plane moved downward and forward along the condyle path, and the left condyle moved up-

ward and backward in the glenoid fossa, as the incisor point moved downward and backward. This movement, like the right lateral glide, originates in a rotational area.

The Lateral Glides.—Gysi[15] has been generally credited with being the first man to interpret correctly the tracing made by the incisor point in the horizontal plane during lateral movements, the transverse vertical plane. Gysi explained the movement of the incisor point in the horizontal plane only, although he does have a picture of himself[17] showing a gothic arch in the transverse vertical plane. Hildebrand[18] shows the lateral movement of the incisor point in the transverse vertical and sagittal planes, and condylar movements in the sagittal plane, by means of roent-

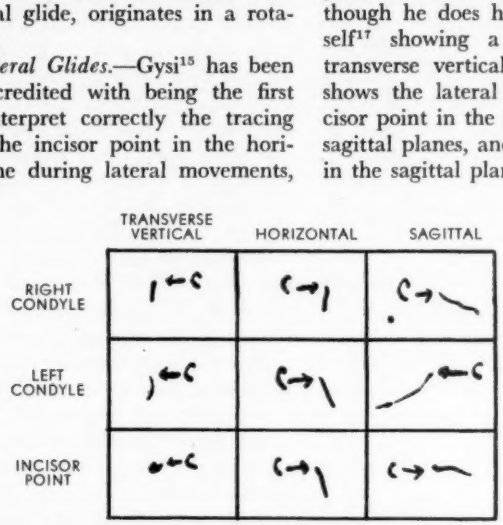

Fig. 11.—Three dimensional tracings of protrusive mandibular glide of patient A.

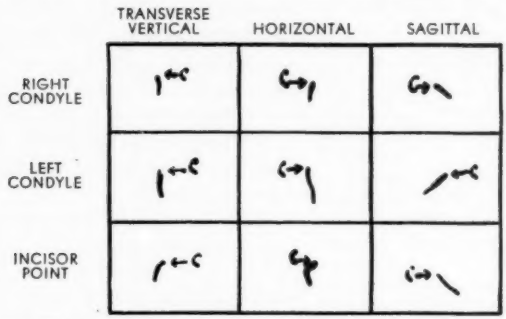

Fig. 12.—Three dimensional tracings of protrusive mandibular glide of patient B.

although Balkwell[16] first described this tracing. Gysi called this tracing the gothic arch, the center of which he designated as a means for locating centric relation. He also described and measured the Bennett movement (movement of the condyle in the horizontal plane) and corroborated the earlier works of Walker and Luce. None of these investigators traced the movement of the condyle in genograms. We were unable to find in the available literature any mention of condylar movement in the transverse vertical plane, or the complete picture of this movement in three dimensions at three points.

The facebow used in these experiments was designed with the stylus at the incisor point in the horizontal plane on the maxillae rather than the mandible. Most

of the commercially sold instruments for obtaining centric relation in full denture construction by means of the gothic arch have the stylus on the maxillary part. The tracing of the arch must then be interpreted in reverse. Figure 10 shows two gothic arches, A C B and D C E, which can be formed by the same individual, depending on the location of the stylus and the tracing plate. If the stylus is on the maxillae and the tracing plate on the mandible, the gothic arch D C E is traced in the horizontal plane, at the incisor point. The line C D, which is on the left side of the patient, is the tracing of the movement into a right lateral glide. C E is the tracing for the left lateral glide and the protrusive tracing is backward from centric position. The true movement of the incisor point is demonstrated when the stylus is on the mandible and the tracing plate on the maxillae. Then the gothic arch A C B is formed, with the tracing on the same side toward which the mandible moves; since A C is the line made by a left lateral glide, and C B is the line made by a right lateral glide and the protrusive tracing is forward from centric. Point C, which is centric relation, is in the same position, irrespective of the location of the stylus.

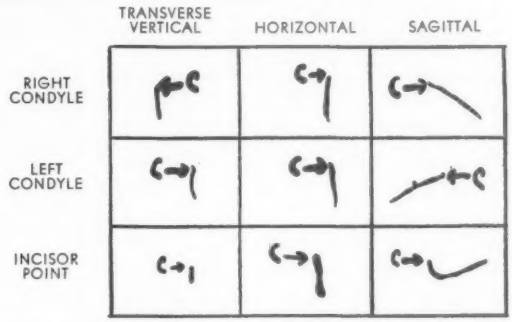

Fig. 13.—Three dimensional tracings of protrusive mandibular glide of patient C.

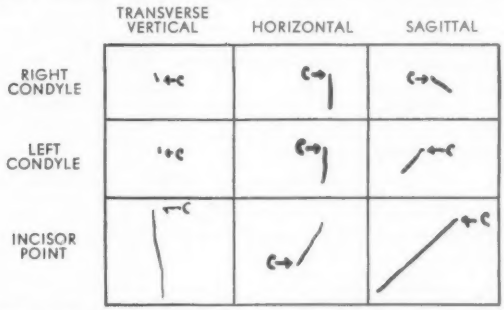

Fig. 14.—Three dimensional tracings of opening movement of the mandible of patient A.

Protrusive Mandibular Glide.—The tracings of a protrusive gliding movement of the mandible, guided by both the condyles and the teeth of patients A, B and C (Figs. 11, 12 and 13), demonstrated that the right and left condyle moved downward from centric relation in the transverse vertical plane, inward and forward in the horizontal (Bennett) plane and downward and forward in the

sagittal plane (condyle path). The incisor point in the transverse vertical plane in patient A had a slight movement downward, then upward. In patient B, the tracing was downward and to the right, while in patient C it moved downward. The movement in the horizontal plane was forward to the left for patient A, forward to the right, then left for patient B, and forward for patient C. The movement in the sagittal plane was downward and forward.

The protrusive movement is not a movement of pure translation or slide, since, it is obvious, if it were, all general directions would be the same. The directions of the movement of both condyles for patients A, B and C were essentially the same, but the slight variability between the right and left sides in the angle of inclination of the condyle path, the Bennett movement and the transverse vertical movement in combination with the differences of the overbite of the anterior teeth resulted in the dissimilarity of the tracings and in the general direction of movement in the region of the incisor point.

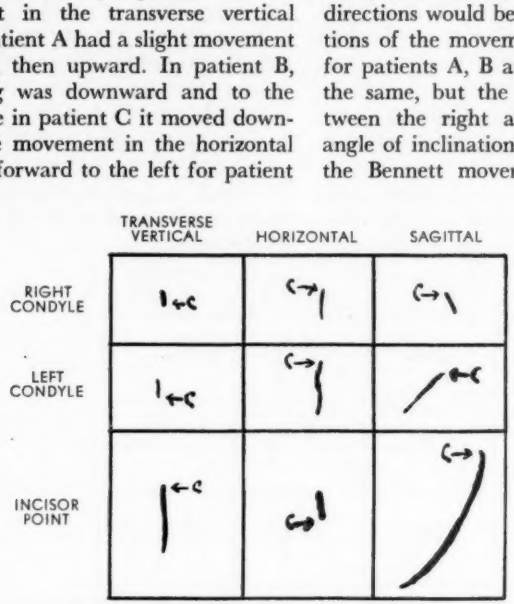

Fig. 15.—Three dimensional tracings of opening movement of the mandible of patient B.

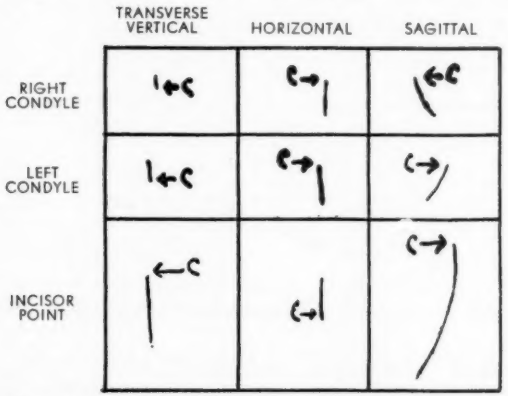

Fig. 16.—Three dimensional tracings of opening movement of the mandible of patient C.

The Protrusive Glide.—This movement, first charted by Christensen,[19] is the basis for the intra-oral technic of bite registration in complete denture construction. Christensen's work was concerned primarily with the movement of the condyle as an aid for setting the articulator adjustments. Gysi referred the protrusive movement to the incisor point in the horizontal plane and to the condyles in the sagittal plane, and showed their character. No reference of this movement to the transverse vertical in the transverse vertical and horizontal were slightly to the left for patients A and B. The movement at the incisor point in the transverse vertical plane was downward; in the horizontal plane, it was backward, and in the sagittal plane, it was downward and backward. Patient A differed from patients B and C in the transverse vertical and horizontal planes, where the general direction of movement was the same, but toward the left side.

It was found that, in a very small

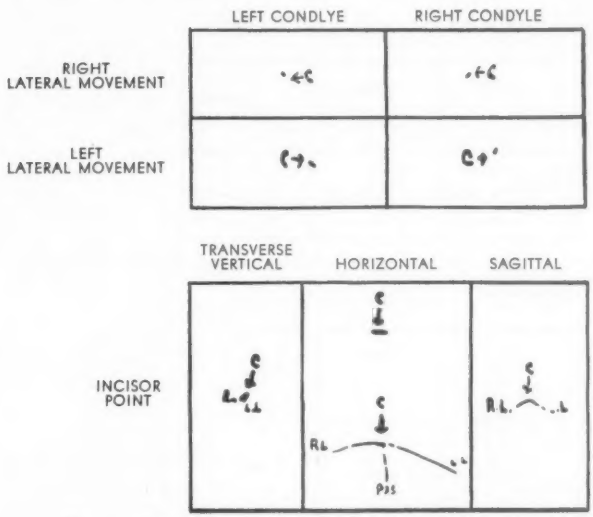

Fig. 17.—Three dimensional tracings of "arcuate movement" of patient C.

plane in the region of the condyles or the incisor point was found.

Opening Movement of the Mandible.—The characteristics of the opening movement, as found by examination of the tracings of patients A, B and C (Figs. 14, 15 and 16), demonstrated that the right condyle moved upward in the transverse vertical plane, forward in the horizontal plane and downward and forward in the sagittal plane. The directions of movement for the left condyle were similar, except that the movements opening, such as the depth of the cusps of the teeth, the condyle moved downward and forward in the sagittal plane. (Fig. 17.) The limits allowed by Rupert E. Hall[20] were used to test the movement of the condyles; i.e., opening movement until the cusps were cleared. Hall found and described a tracing of 180 degrees, made at the incisor point only in the horizontal plane, with this opening, which he called the arcuate or three-dimensional tracing. He compared this tracing with a gothic arch or a so-called

two-dimensional tracing made in his mouth. The difference between the two can be readily seen by any one wishing to follow this technic. This, however, is not an equitable comparison, for when the mandible is moved on a flat plane to form the gothic arch, the vertical dimension has been opened the thickness of the plate. Consequently, the two tracings are not taken at the same level in either the transverse vertical or sagittal planes, and so could not be compared in the horizontal plane. By the use of our special facebow, it was found that, on the horizontal plane, the incisor point did trace an arcuate tracing. A gothic arch was made in the transverse vertical plane, while a modified gothic arch was traced in the sagittal plane. This arcuate tracing was then superimposed on the tracing which was made of a mandibular glide in the horizontal plane, and it was found to be just a small segment of the larger gothic arch.

Therefore, the opening movement is not a simple hingelike movement. If it were, both condyles would remain in position in the glenoid fossa and just the incisor point would exhibit movement. It is apparent also that when the opening movement occurs on the horizontal plane at the incisor point, a tracing is made back of centric relation. It can be seen that this tracing differs from the protrusive tracing in the direction of movement from centric relation; i.e., the opening movement is back of centric relation, while the protrusive movement is in front of it. This difference is also noted in the transverse vertical plane in

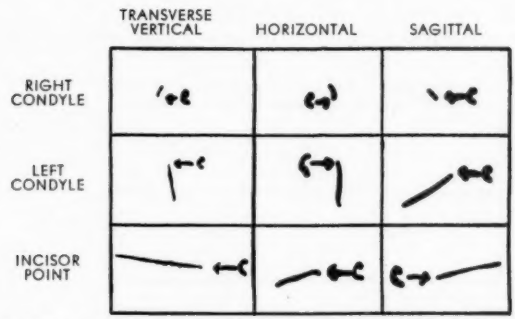

Fig. 18.—Three dimensional tracings of right lateral mandibular glide of patient D.

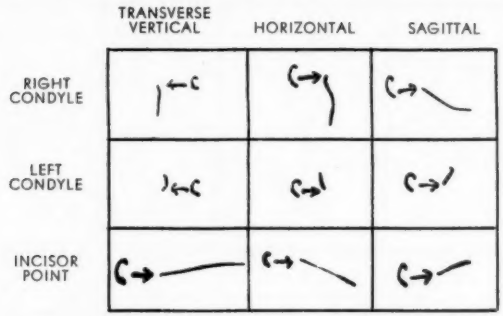

Fig. 19.—Three dimensional tracings of left lateral mandibular glide of patient D.

the region of the condyles. In the protrusive movement, the tracing goes downward from centric relation, while, in the opening movement, the tracing goes upward from centric relation. This variability should be carefully noted, because its importance will be emphasized in relation to a stroke of mastication.

The Opening Movement.—These characteristics of the opening movement are still creating controversies.[21] Higley and Logan,[22] who recently made a study of this component by comparing roentgenograms in the sagittal plane only, found that the condyle moved progressively forward as the mouth is opened. Thompson[23] agrees with this finding by the use of the cephalometric method. The opening axis of the mandible cannot be on the condyle cord, since the condyles move downward at the least opening of the incisor point. The present study of this component is the most nearly complete, since the movement has been referred to the three dimensions rather than to just one plane.

Gothic Arch in an Edentulous Case.—An edentulous patient (D) was selected to determine whether the gothic arch for bite registrations in complete denture construction is two dimensional. The facebow attached to bite-blocks separated by a central bearing screw was adjusted as previously described. The general directions of movement for the right and left condyles in the three dimensions (Figs. 18, 19 and 20) were the same as those made by patients A, B and C, although, of course, the angle and the extent of movement varied. The main

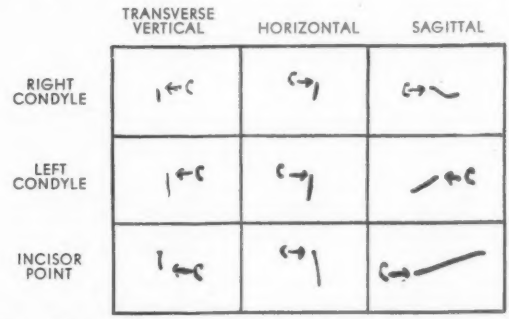

Fig. 20.—Three dimensional tracings of protrusive mandibular glide of patient D.

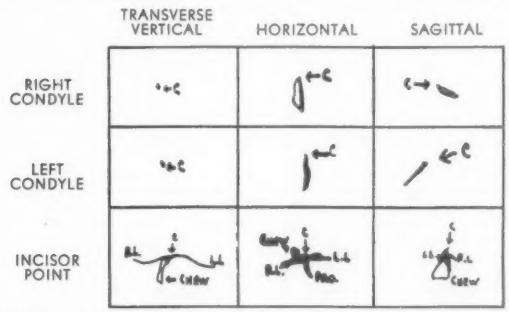

Fig. 21.—Three dimensional tracings of one masticatory stroke of patient A.

difference between the edentulous and the dentulous mouth occurred at the incisor point. The movements of the components in the horizontal plane for patients A, B, C and D were the same; i.e., a gothic arch was formed. The direction of these components was reversed for patient D in the transverse vertical and sagittal planes. The protrusive tracing, for example, in the transverse vertical plane for patient D was upward as compared with the downward tracing made by patients A, B and C. Similarly, the tracing on the sagittal plane was upward and forward for patient D as compared with the downward and forward movements of patients A, B and C. The lateral components of patient D are similar in their variability to those of patients A, B and C. This difference can be readily explained by the fact that since there were no teeth in the mouth of patient D to force the mandible down, the tracing showed the direction was upward in these two planes. The gothic arch tracing is three dimensional even in an edentulous mouth. Were it not, a straight line parallel to the horizontal plane would have been obtained. This experiment demonstrates the necessity of referring mandibular movement to the three dimensions in order to secure a complete picture.

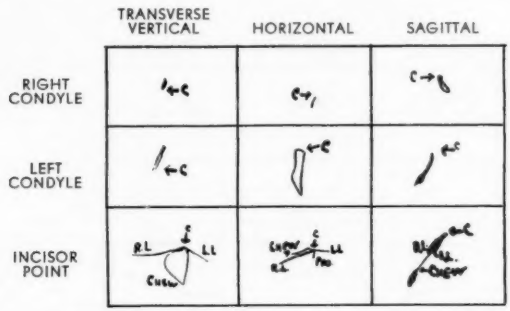

Fig. 22.—Three dimensional tracings of one masticatory stroke of patient B.

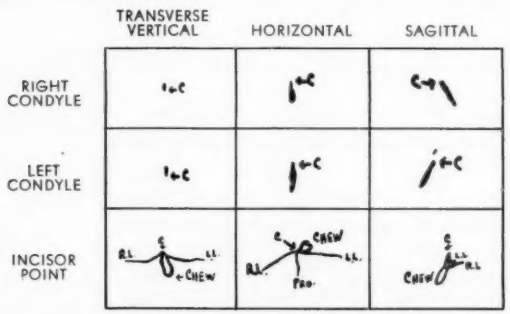

Fig. 23.—Three dimensional tracings of one masticatory stroke of patient C.

ACTUAL STROKE OF MASTICATION

A tracing of a single stroke of mastication demonstrates that, in patients A, B and C (Figs. 21, 22 and 23), the right condyle moved upward and then downward, back to centric relation in a

motion roughly ellipsoidal in the transverse vertical plane, while it moved forward and then backward to centric relation in the same motion in the horizontal plane, and downward and then upward with an ellipsoidal motion in the sagittal plane. The movements in the various planes which were traced by the left condyle were of similar character. The incisor point moved in an ellipsoidal direction downward and slightly laterally to the chewing side, then upward to centric relation in the transverse vertical plane. The movement in the horizontal plane was backward and laterally, then forward to centric relation, while the movement in the sagittal plane was primarily downward and backward to the limits of opening and then back, upward and forward to centric relation.

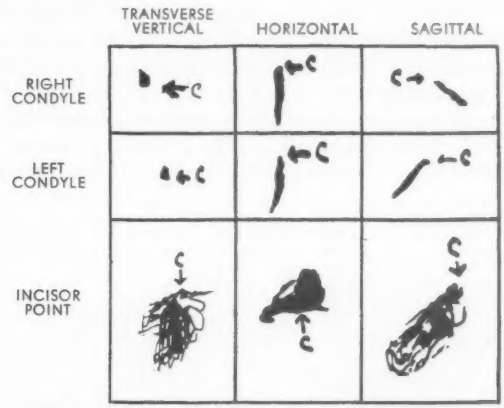

Fig. 24.—Three dimensional tracings of multiple masticatory strokes of patient A.

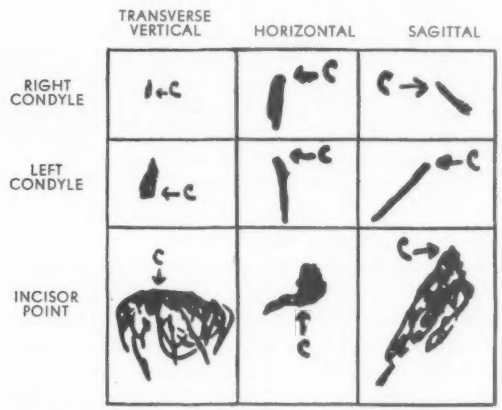

Fig. 25.—Three dimensional tracings of multiple masticatory strokes of patient B.

Tracings made of multiple strokes of mastication as directed to the right and left side made the record shown in Figures 24, 25 and 26. The tracings made by the right and left condyles in the three dimensions were so numerous that

they appear as one solid mark. The general direction of movement is the same as that described above by the single masticatory stroke. The wide variety of strokes is best shown in the tracing at the transverse vertical plane of the incisor point. Here the tracings go downward to the left or right, then upward, to end at centric relation. This same description applies to the tracings on the sagittal plane, where the general directions follow those of the opening component. A heavy tracing is made on the horizontal plane back of centric relation. The side toward which the greatest same plane as the occlusal plane. He continues:

> This would indicate that the mandibular foramen is the least point of motion in the movements of the mandible so that no trauma be incurred by the mandibular or inferior dental division of the fifth cranial nerve during jaw movements.

Sicher[25] concurs in this finding and reports this fact as a characteristic distinguishing man from the chimpanzee.

The Masticatory Stroke.—The masticatory stroke has been neglected by the majority of the investigators of this subject, who have dealt mainly with the

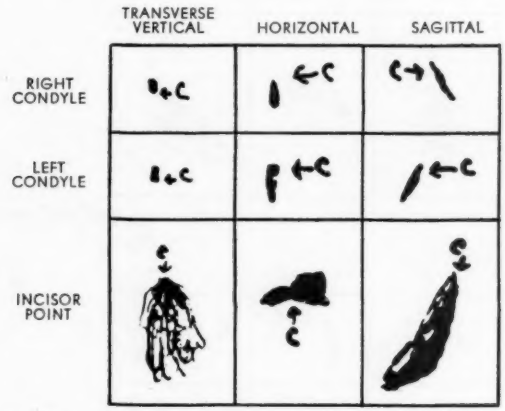

Fig. 26.—Three dimensional tracings of multiple masticatory strokes of patient C.

number of masticatory strokes were made is apparent on the backward projection of the tracing.

It is demonstrated in the condylar tracings that the center of the origin of these masticatory movements could not possibly be near the heads of the condyles, because the direction of movement is upward in the transverse vertical plane from centric relation. This area must be below the head of the condyles and probably has its location in the region of the mandibular foramen as suggested by H. J. Prentiss,[24] who states that the mandibular foramen from birth on is on the characteristics of the components of mastication. Hildebrand, as has been noted, analyzed the masticatory stroke in only two planes, as transverse vertical and sagittal, and ignored the horizontal plane, which is the one most important plane in the clinical application of this subject to dentistry. Gysi[26] says, "I now regard the record of the lateral movements of the mandibular incisor point, that is, the Gothic arch, as the most important individual record of movements." We can agree that the record of the movement of the incisor point is the most important one in dentistry, but it is not

the record of the lateral movements of this point. The actual movements of mastication must take predominance over those of any other component. The movements of the incisor point in mastication are at variance with the movements of the components. It was found, in these tracings, that this comparison could be made at the incisor point in all three planes. (Figs. 21, 22 and 23.) The movements at the condyles were so slight that a comparison in this region would only confuse the tracing. It is interesting to observe that the protrusive component is not incorporated in a masticatory stroke, because the general direction of the condyles in the transverse sagittal plane is upward from centric relation. A comparison of the components and the masticatory stroke in the transverse vertical plane at the incisor point shows a slight congruency of the lines toward centric relation. The masticatory movement in the sagittal plane was roughly parallel to, and in some places congruent with, the opening component. The most important discovery was made in the horizontal plane, where it was found that the masticatory stroke is not within the confines of the gothic arch, but posterior to centric relation; which confirmed the statement above that no protrusion is used in mastication. This finding was so startling that a possibility of the bulkiness of the facebow being responsible was considered; for the same phenomenon occurred in all the patients studied. (Figs. 21 and 23.) Therefore, it was decided to check this tracing by means of stroboscopic photographs.

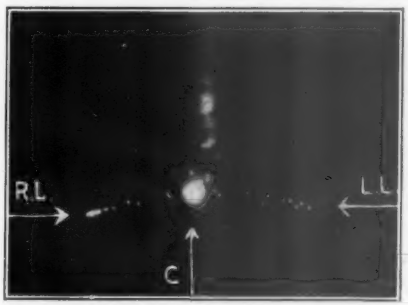

Fig. 27.—Stroboscopic photograph of the lateral components of the gothic arch taken in the horizontal plane of patient E.

STROBOSCOPIC PHOTOGRAPHS

Stroboscopic photographs of patient E were obtained by the utilization of Professor Edgerton's light, whereby movement can be stopped and its direction shown on a photographic plate, at any speed up to one three-thousandths second. It was found by experimentation that twenty-five visual images per second were necessary for a clear picture of the direction of the mandibular movement. Figure 27 shows the lateral components that form the gothic arch. Figure 28 is a horizontal view which demonstrates that a masticatory stroke is posterior to centric relation and is not within the confines of the gothic arch. Simpson,[27] in speaking

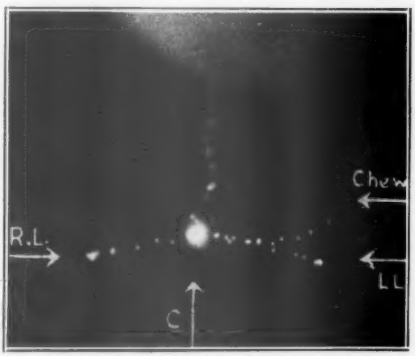

Fig. 28.—Stroboscopic photograph of the lateral components of the gothic arch and a single stroke of mastication taken on the horizontal plane of patient E. This photograph illustrates the fact that the masticatory stroke is not made within the confines of the gothic arch.

of the gothic arch summed the past knowledge of this type of mandibular tracing, when he stated that the gothic arch "always presents a definite included angle averaging about 120 degrees. It is this included angle or range which we are concerned with in denture construction." This statement is true if we are only concerned with the gliding components of mandibular movement. But we do not chew with a mandibular glide and the areas with which the glide and the masticatory stroke are congruent are just a very short distance at centric relation. Figure 29 demonstrates a multiplicity of mandibular strokes with the protrusive glide added to the picture. Again the masticatory movements are not contained within the gothic arch and we see that there is absolutely no protrusion in a masticatory stroke. A steel pin bearing a highly polished steel ball as an indicator was rigidly cemented in the interproximal space between the two mandibular central incisors. The incisor point was used in this experiment because, as demonstrated by the graphic method, the movement at the condyles is so slight that interpretation of the photographs would be difficult. The face was blackened to decrease the reflections, so that the picture would show just the paths of the mandibular movement.

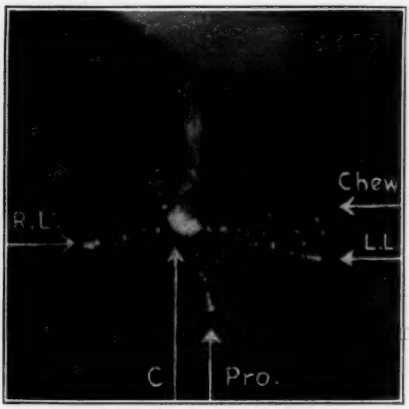

Fig. 29.—Stroboscopic photograph of the lateral and protrusive components of the gothic arch and multiple strokes of mastication; demonstrating that the protrusive component is not utilized in a masticatory stroke, and that the masticatory stroke is beyond the confines of the gothic arch.

CENTRIC RELATION

The importance of centric relation can be readily seen both from the graphic tracings and from the stroboscopic pictures when it is observed that all masticatory endeavor ends at this point. Logically, for any reconstruction work in dentistry, the gothic arch taken in the horizontal plane at the incisor point can be used for obtaining centric relation. Its value for the condylar adjustments of any articulator is questioned, as the mandibular movement is not contained within the gothic arch, but is back of centric relation. The futility of adjusting the

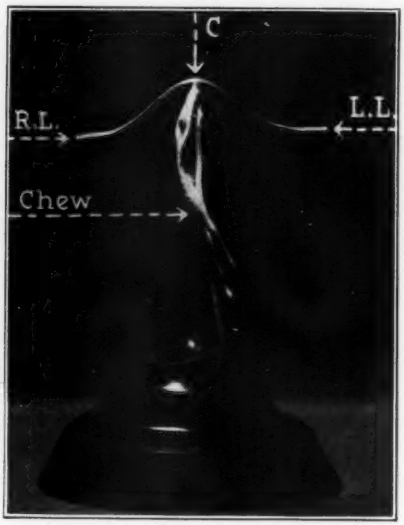

Fig. 30.—Model which demonstrates differences between glide and masticatory stroke in transverse vertical plane at incisor point.

condylar paths by means of a sagittal tracing in the region of the condyles is also apparent when one compares the condylar tracings made in the same patient by the various components of mastication. This comparison of movement at the condyles shows that the opening component in mastication is most important and the chewing cycle follows this component most closely. The protrusive relations are relatively unimportant because incision is a static relation; i.e., when food is to be incised, the jaw is already opened, and is then closed in a forward position to allow the edges of the incisors to make contact. It is, of course, impossible to incise any food whatsoever if the jaw glides forward in a protrusive movement with the teeth in contact.

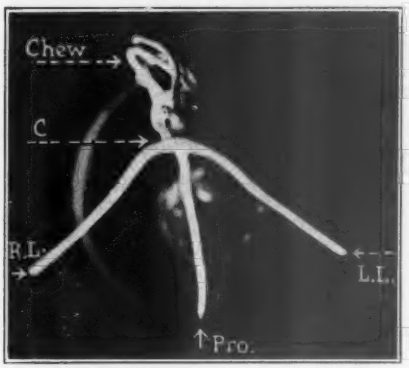

Fig 31.—Model taken in horizontal plane. It can be seen that the strokes of mastication are not contained within the gothic arch, and that the protrusive component is not used in mastication.

SPHERICAL MOVEMENT OF THE MANDIBLE?

An analysis of these various tracings and photographs reveal nothing that could be construed as resembling a spherical movement of the mandible either in a glide or in an actual stroke of mastication in patients A, B, C and E. If lines were erected perpendicular to the tracings made by patient D, in the lateral and protrusive glide, a center for such movement can be evolved. An edentulous patient's movement at the incisor point in the transverse vertical and sagittal planes is just the reverse of what was found in the dentulous patients. Consequently, these edentulous tracings should not be taken as criteria for the normal movement at this location. However, the edentulous patient, like the dentulous patient, is not in function on these gliding strokes, but chews with a stroke of mastication.

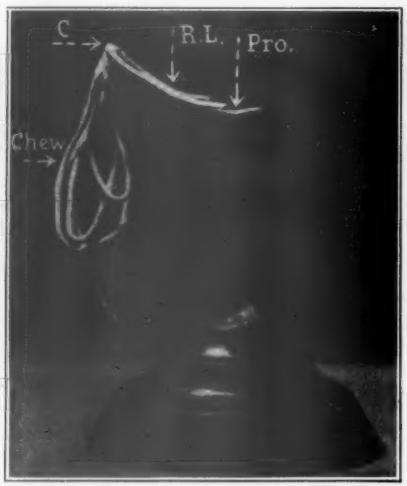

Fig. 32.—Sagittal view of model shown in Figure 30.

MODELS OF MANDIBULAR MOVEMENT

Since many are unable to visualize movement from two dimensional graphs or pictures, models made of wire were used to show the direction in which the incisor point moves in a glide and in a masticatory stroke. Figure 30 is a front or transverse vertical view of the model depicting the glide and some of the various strokes of mastication. The lateral

glides are designated by the wire at the top, with C as centric relation. The masticatory strokes are shown going downward, laterally and then upward, coinciding with the lateral components near centric relation. The gothic arch is shown in Figure 31, from the top or horizontal view, along with the protrusive line. The strokes of mastication can be seen back of centric relation. Figure 32 shows a side or a sagittal view of this model. The lateral components, but not the gothic arch, are visible. The strokes of mastication appear to have a different character when compared with those seen in Figures 30 and 31. In the three views of the other model, the gothic arch appears as we should expect to find it in an edentulous case. In the front or transverse vertical view (Fig. 33), the gothic arch is in a different position from that shown in Figure 30. The top or horizontal view of the gothic arch in Figure 34 is to be compared with the top view of the glide in Figure 31. The side or sagittal view (Fig. 35) is of the lateral components of the gothic arch.

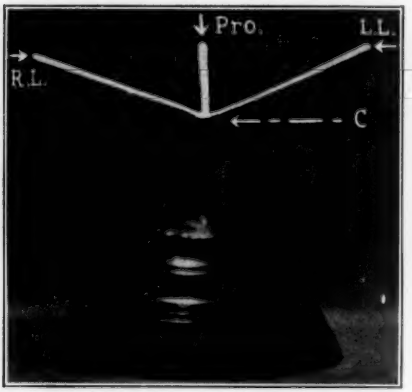

Fig. 33.—Model demonstrating edentulous tracing of mandibular glide in transverse vertical plane at incisor point. (Compare directions of lateral components with those in Figure 30.)

The difference between the wires depicting the lateral components and the straight wires in the edentulous mouth, as compared with the slightly irregular delineation of the lateral components in the dentulous mouth, can be explained by the fact that, in the former case, there are only the condyles and a flat plane to make the tracing, while, in the dentulous mouth, the tracing is made by the combined action of the condyles in the cusps and overbite of the teeth.

These differences between the mandibular glide and an actual mandibular stroke of mastication must be understood if one desires to make dental restorations which are compatible with these movements, and especially in making replacements which involve the greater part of the occlusal plane. Emphasis should be given to L. M. Waugh's[28] statement that the study of "normal occlusion is the basis of the practice of dentistry."

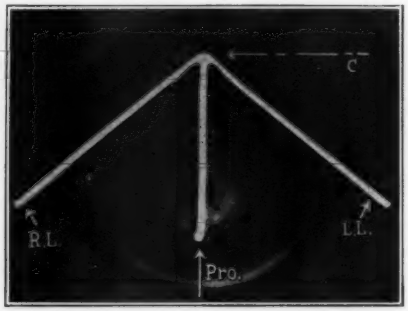

Fig. 34.—Model shown in Figure 33, taken in horizontal plane; illustrating gothic arch.

SUMMARY AND CONCLUSIONS

The physiologic act of mastication can be divided into (1) the incision, (2) the chewing and (3) the swallowing of food. We are primarily concerned with the chewing cycle, since the incision of food is a static relation, and mandibular movements *per se* are not involved in

the swallowing of the masticated food.

The mandibular movements made during the chewing cycle are the mandibular glide and an actual stroke of mastication.

The mandibular glide can be divided into right lateral, left lateral, protrusive and opening movement. It is the combination of some of these components that form an actual stroke of mastication. Three points of observation were necessary to make this study, and this movement was referred to the three dimensions at each location.

Mandibular movements were recorded at the right and left condyles and the incisor point of the mandible with a specially constructed facebow. These movements were referred to three dimensions, which are identified as transverse vertical, horizontal and sagittal.

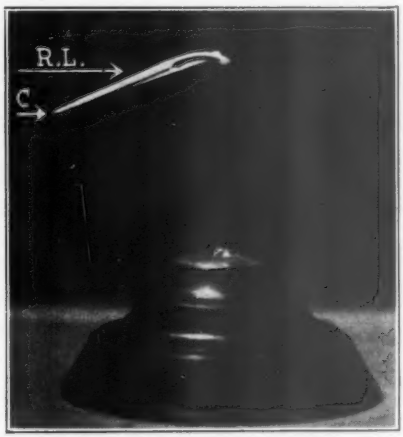

Fig. 35.—Model shown in Figure 33, taken in sagittal plane.

There is no evidence in the literature that three dimensional mandibular movements at three locations have ever been previously studied.

The mandibular movement was traced on waxed glass slides by styluses. These lines were then etched into the glass by means of hydroflouric acid, and thus a permanent record of this movement was made.

The characteristics of each one of the mandibular components as right lateral, left lateral, protrusive and opening were shown and explained. The new findings were recorded, especially as related to the transverse vertical plane in the condylar region, and in the transverse vertical and sagittal planes at the incisor point.

The actual stroke of mastication has been neglected by most investigators. This stroke was described, and it was found that the components used in mastication are the opening and lateral movements. The protrusive component is not used in mastication. The actual stroke of mastication is congruent with the tracings made by the lateral and opening components for a very short distance toward centric relation in all three of the planes.

A startling discovery on the horizontal plane at the incisor point was that the actual stroke of mastication was not contained within the included angle of the gothic arch.

Stroboscopic pictures were used for the first time in dentistry to determine the direction of the movement of the incisor point on the three planes. The components and the actual stroke of mastication were shown on the same picture so that they could be compared. The results were identical with the findings of the graphic method: Only the lateral and opening components are utilized in combination to form a stroke of mastication, which is congruent for a very short distance with the glide near centric relation. The protrusive component is not used in mastication, and the masticatory stroke on the horizontal plane is not within the confines of the gothic arch.

The only clinical purpose of the gothic arch was shown to be the ascertainment of centric relation at a definite vertical opening.

The value of making articulator adjustments by either the lateral movements

of the gothic arch or the protrusive record is questioned. The condylar registration in the sagittal plane for the various components of mastication was so dissimilar that its use in making articulator adjustments is likewise questioned.

It was demonstrated that from neither the three dimensional tracings nor the stroboscopic pictures can it be said that a spherical movement of the mandible occurred during actual mastication.

Models made of wire were used to depict the great differences between a mandibular glide and an actual stroke of mastication, and to show the differences between the glides of an edentulous patient and a dentulous patient at the incisor point.

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THE PATHOLOGIC VITAL TOOTH; WITH REPORT OF CASES

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WHILE the subject of the pathologic vital tooth is not new, attention seems to have been diverted from it, in considering focal infection, by the mass of literature devoted to the pulpless tooth, and by the confusing clinical and roentgenographic evidence of pathogenicity in the case of the vital tooth.

However, to go back no farther than 1919, we find an article entitled, "Bacteriology of Vital Pulps,"[1] in which the authors found in 115 freshly extracted teeth with grossly normal pulps four classes:

1. Those that were entirely normal (no positive cultures).

2. Those that showed pyorrhea, including even slight degrees of gingivitis (42 per cent positive cultures).

3. Those with dental caries only (43 per cent positive cultures).

4. Those presenting both caries and pyorrhea (40 per cent positive cultures).

We do not know how many of the teeth that showed positive cultures were inoculated during the extraction, nor how many cultures were positive because of a passing bacteremia; but this report indicates at least that pulps can become infected from caries alone, from pyorrhea alone or from a combination of both conditions.

How many cases of pulp infection clear up when decay is removed or when pyorrhea is controlled, we do not know, but I have become convinced that more cases fail to clear up than have been believed to do so.

Rickert[2] has this to say of the infected degenerating pulp:

> The attention of the dental profession has been so tenaciously focused on pulpless teeth as possible foci of infection that another, in many respects more serious, aspect of dental infection has been rather generally overlooked. I have reference to the vital but infected and slowly degenerating pulp.

If Henrici and Hartzell[1] found in grossly normal pulps infection that might enter the blood stream, it is reasonable to suppose that degenerating pulps are a more serious source of infection.

Indeed, Thoma says,[3]

> Research and clinical observations, carried on for the last two years, have disclosed that chronic infection of the pulp in so-called vital teeth is a particularly potent focus of infection. It is most frequently overlooked in oral examinations because it is very difficult to diagnose.

A year later, in 1929, Thoma[4] reports on "A Comparison of Clinical, Roentgen, and Microscopic Findings in Fifteen Cases of Infected Vital Pulps":

> It is interesting to note that, in fourteen cases of adult patients, the pulp infection was of the chronic type of inflammation. The symptoms were indefinite, and only occasionally experienced . . ."

These reports of Thoma would indicate that we are overlooking even gross pathologic conditions of vital pulps, and that because of difficulty in diagnosing such conditions, there may be some excuse for overlooking them.

Read before the Section on Operative Dentistry, Materia Medica and Therapeutics at the Eighty-Third Annual Meeting of the American Dental Association, Houston, Texas, October 29, 1941.

Two other investigators,[5] one a physician, confirm the idea that diagnosis of infection in vital pulps is difficult:

> Unfortunately, there are no characteristic signs or symptoms from the vital tooth with an infected pulp; indeed, the diagnosis is usually debatable. Pain is rarely produced. Physical findings such as cavities, occlusal defects, and mobility tests are not dependable criteria. Vitality tests are normal since the nerve is not destroyed in the early or moderately advanced case. . . . The dental roentgenogram offers the most promising diagnostic aid.

It is true that one will often suspect a diseased pulp in a tooth from the roentgenographic findings when the objective and subjective symptoms are negative. Cases will be reported later in this paper in which roentgenographic findings are negative or uncertain, and yet, when the extracted tooth was opened, the pulp was found to be liquefied.

Pain or absence of pain is not an indication one way or the other, since, as stated above, infected teeth may be free from pain. On the other hand, a painful tooth may have a hyperemia that clears up under treatment or even spontaneously.

The uncertainty of symptomatology in diseased vital pulps is confirmed by Stephan[6]:

1. The *normal* pulp is without painful symptoms, gives an average response to heat and cold stimuli, gives a response to the electric tester at a variable index, and radiographically shows no periapical change.
2. The *atrophied* and *degenerated* pulp is without painful symptoms; generally gives an average response to electric, hot and cold stimuli, but may give a variable, or no response, and roentgenographically shows no periapical change, although it may show secondary calcification in the pulp canal. This indicates that degenerative changes cannot be reliably diagnosed clinically.

Austin and Waggener,[7] with a wide experience in the use of the electric tester, have this to say:

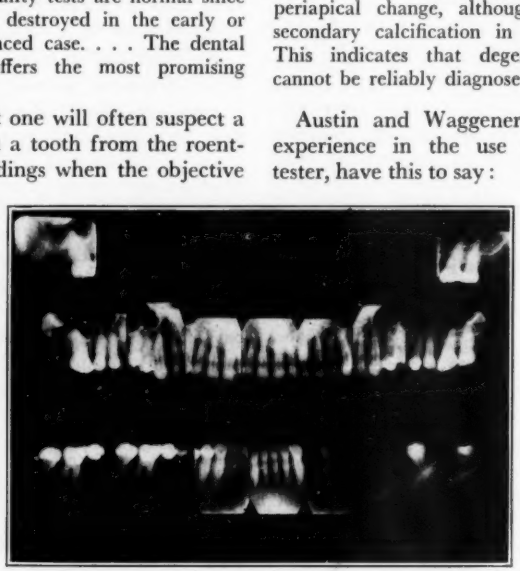

Fig. 1 (Case 1).—Complete roentgenographic survey.

Pulp tests often indicate only that the nerves of the pulp respond to stimuli. This may occur in a healthy normal pulp or in a diseased pulp.

Reiss and Furedi[8] found, in a carefully conducted unipolar electric tester vitality test, fortified by a microscopic study of the 130 teeth tested, that 63.5 per cent of teeth in the normal group had nearly normal pulps, and the 36.5 per cent listed as pathologic included 19 per cent with pulps showing marked atrophy, a change that, apparently, could not be distinguished by the vitality tester.

While no attempt is made in this

paper to look into the causes of infection of vital pulps, causes must be considered in an endeavor to determine whether a pulp is diseased. In a clinical examination, we look for decay, either primary or secondary. We test the tooth for vitality, trauma and subgingival infection. But it is in the roentgenogram that the most convincing evidence may be found. On the other hand, as no test is free from error, as no evidence is infallible, we cannot say that the roentgenographic findings are final.

The widening of the periodontal space at the root end, together with the thickening of the lamina dura, or a filling in of the intratrabecular spaces with radiopaque substance in the bone around the root end is usually indicative of infection within the pulp. However, as clinical experience has shown, we may even have liquefied pulps without the foregoing types of roentgenographic evidence. Conversely, we may have these types of roentgenographic evidence and yet the pulps will apparently recover under appropriate treatment, as the periapical changes first noted disappear, and the teeth become comfortable and remain so for years.

The question of the effect on the health of the pulp of changes within the pulp chamber that can be seen in the roentgenogram is one of absorbing interest, and one that has not been, and probably never can be, answered.

It seems that the shape and size of the pulp chamber can be materially changed without damage to the pulp; but the roentgenographic evidence of calcifications within the pulp, as shown by areas of radiopacity within the radiolucent outlines of the pulp chamber, is evidence that admits of much debate.

That a high percentage of pulps have some calcification has been demonstrated by Kronfeld[9] and others.

Kretschmer and Seybold[10] made such strong statements regarding pulp nodules in 1936 and advised such radical procedures that the retention of any considerable number of teeth seemed highly improbable, since pulp nodules can be seen in teeth soon after eruption and, in some instances, in nearly every tooth in the mouth.

Upon further research, Kretschmer modified his original radical statement, taking a position that is more tenable, and one with which I can more nearly agree; i.e., that teeth with pulp nodules are not necessarily a source of infection,

Fig. 2 (Case 1).—Right mandibular second bicuspid and first molar, which were extracted first, and remaining molars, which were finally extracted.

but, in a fairly high percentage of cases, they are a source.

Other writers[11] discount the findings of Kretschmer and Seybold, because of results of their own research work.

Cahn[12] says that calcific degeneration is never found in healthy tissue.

It seems from the foregoing evidence that vital teeth can be infected and a source of infection; that the pulp infection in these teeth can arise from caries, periodontoclasia, pulp calcification or trauma, or can even have an undeterminable cause. It seems further that infection of a vital, degenerating or even necrotic pulp may be most difficult to diagnose by the usual methods. One must conclude, therefore, that, because of the potentialities for serious metastatic disturbances from an infected vital tooth, we should use every means at our command to determine whether a vital tooth about which there is any shadow of doubt falls in the class of the pathologic vital tooth.

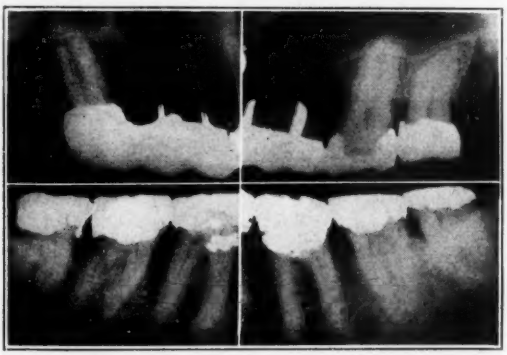

Fig. 3 (Case 2).—Molars which were vital, but the pulps of which were found to be pathologic when teeth were removed and opened.

REPORT OF CASES

CASE 1.—Mrs. A. L. T., aged 36, first seen May 19, 1930, gave a history of recurring iritis, particularly in the spring of the year. Her husband was an oculist and, besides giving the eyes the best of care, had every known physical examination made in an endeavor to find a cause of the iritis. No cause was found and even the teeth were given a clean bill of health by three different men. This particular year, the iritis persisted until blindness was imminent.

Upon interpretation of the roentgenograms shown here (Figs. 1 and 2), and in consideration of the prompt response to vitality tests of the right mandibular second bicuspid and first molar, it was decided to remove these teeth and, at the same time, it was stated that all of the molars might have to be removed because of pulp calcification and possible pulp infection.

Upon removal of the first two teeth, the iritis cleared up and the vision was better than it had been for some time. However, there was a mild attack in 1939, and one in 1940 of greater severity. The rest of the molars were removed in November 1940, and not only has there been no recurrence of the iritis, but also the vision has steadily improved.

The pulps of all of these teeth were macroscopically pathologic, and certainly it seems as clear a case of cause and effect as we could possibly have. Of this, the patient, the husband and the consulting oculist were fully convinced.

CASE 2.—S. B., a man, aged 65, had been feeling below par for some time and had been battling a persistent prostatitis. A supernumerary tooth above the right maxillary central incisor had been removed November 23, 1938, with some benefit, but

now, February 29, 1940, there was again pus in the prostate.

Clinical oral examination revealed that the molar teeth were hypersensitive to ice, and as they were not comfortable, it was decided to remove and examine one or two. As the pulps were found (Fig. 3) to be diseased, all of the mandibular molars and all of the maxillary teeth were finally removed.

The patient reported some six months later that the prostatitis had cleared up and that the general health was greatly improved. In his own words, "I feel ten years younger than I did before the teeth were removed." In answer to a query regarding his general health August 12, 1941, he replied, "The prostate has been infection free ever since the teeth were removed.

CASE 3.—A. B., a man, aged 55, who had an unusually good health record, had had his teeth under observation over a period of years, but there had been a good many losses in early life.

In 1933, the left maxillary central incisor responded normally to ice shock, the left cuspid was hypersensitive, the first bicuspid was hyposensitive and the third molar hypersensitive. In 1934, the condition was the same. In January 1936, it was unchanged except that the cuspid was now normal instead of hypersensitive. (Fig. 4.)

From December 1936 on, one pulp after another became inflamed and had to be removed, first the maxillary left cuspid, then the left central incisor, followed by the right mandibular first bicuspid. In January 1937, headaches of a severe paroxysmal character developed, confined mostly to the left side of the temple. The pulpless teeth on this side of the jaw were removed, with some favorable results, but which proved to be temporary.

The medical record shows that, in January 1937, the patient was much overweight. In February, a blood chemistry test showed a nonprotein nitrogen of 62 mg. per hundred cubic centimeters of blood and 2.2 mg. of creatinine. The patient was placed on a low protein diet, 30 gm. daily, with reduction in fats to reduce the weight. Gradually, he began to improve. The weight loss was gradual and the sense of well-being returned. May 1, the nonprotein nitrogen was 32 mg. and creatinine 1.8 mg.

Fig. 4 (Case 3).—Affected teeth before pulps died and after root canals were filled.

There has been no further loss of pulps nor return of headache.

CASE 4.—Mrs. B. L., seen May 23, 1939, stated that her general health was perfect except for trouble with a bridge on the lower left side and some rheumatism. She was much overweight.

The lower bridge to which she referred

had been removed, but she complained of aching of the bicuspid for the previous two months or more. Her dentist could find nothing wrong with the tooth. Its response was negative to ice shock, but was elicited on the fifth step of the electric tester. In view of the history, the tooth was removed, and it was found that the pulp was necrotic. The second molar then became painful, and when it was removed four days later, the pulp was found to be diseased. (Fig. 5.)

After the removal of these teeth, the gums were treated and necessary fillings inserted and the right maxillary fixed bridge was reconstructed.

During the summer, the patient complained of pain in the left maxillary molar region. The teeth were again tested for vitality and gave a normal response to both ice and electricity. The paranasal sinuses were examined, but were reported negative. The patient was referred to an internist, who could find no cause for the pain. He considered the patient neurotic and gave her injections, which relieved her temporarily.

She complained of backache and headache during the fall of 1939 and winter of 1940 and also complained constantly of pain in the left maxillary molar region. It was finally decided that the first molar was the cause of the trouble and it was removed April 7, 1940, and, on the patient's insistence, the adjoining second molar was removed eleven days later. In each instance, the teeth were cracked open immediately after removal and the pulps were found to be liquefied. (Fig. 6.)

Temporary relief was experienced after the removal of the molars, but soon the patient complained of the same type of pain in the bicuspids, which she said had a feeling of being wooden. The bicuspids were removed August 7 and the adjoining cuspid September 3. A month later, the left lateral incisor was extracted. By this time, the idea of saving any of the maxillary teeth had been given up, since the patient now complained of pain in the right maxillary teeth of the same character as that experienced on the left side. These teeth were therefore removed and each tooth had a diseased pulp. In October, an immediate denture was made.

Fig. 5 (Case 4).—Complete roentgenographic survey made when patient was first seen, and two views of left maxillary region after removal of some of the teeth.

At this time, the patient changed physicians and I requested a blood chemistry test, with particular reference to the nonprotein nitrogen. The report was as follows: Nonprotein nitrogen, 42 mg. per hundred cubic centimeters of blood; urea nitrogen, 21; sugar, 121.9. These were all at the extreme upper limit of normal. The physician prescribed a corrective diet.

The patient reported several months later that the backache was gone and that she felt better than she had for some time.

May 9, 1941, she reported that there had been some rheumatism in the left wrist for the previous two weeks and a swelling over the right mandibular first molar. The swell-

ing was hard, with no fluctuation. There was no discomfort in the area, and since the tooth was not uncomfortable and was normally vital, nothing was done. The patient also reported an aching in the lower anterior teeth similar to the distress in the upper teeth that eventuated in their loss.

At this time, she consulted another physician, and, at my request, a blood chemistry examination was made, a nonprotein nitrogen of 28.2 being revealed.

September 3, the patient reported that she was feeling much better, having lost 20 pounds under a new diet régime. She had no backache and no headache. The enlargement of the tissues on the buccal aspect of the right mandibular first molar was the same as four months previously, but a roentgenogram disclosed nothing and there were no subjective symptoms.

In view of the history of the previous case and the disclosure of a high nonprotein nitrogen in each case, the question arises as to whether there is any connection between the diseased vital pulps of apparently normal teeth and a high nonprotein nitrogen. A search of the literature throws no light on the subject.

CASE 5.—Mrs. W., aged 60, seen February 27, 1941, had been in poor health for some time and had been under the care of an internist since the preceding November. She had improved somewhat.

The left eye had given serious trouble since the previous fall and the right eye for a shorter time. The oculist's diagnosis was "plastic iritis with permanent damage to the left eye."

A diagnosis of degeneration of the pulps in the four second molars was made from roentgenographic, objective and subjective findings and symptoms, although the pulps were vital in all of the teeth. (Fig. 7.)

The right maxillary second molar was removed March 7; the left maxillary second molar April 8; the left mandibular second molar May 6, and the right mandibular second molar May 20. A severe reaction, or exacerbation of symptoms, in the eyes followed the first two extractions. The intervals between extractions were rather long partly because of the poor physical condition of the patient and partly because the oculist wished to have time to observe results. The right eye began to improve after the first two teeth were removed, but the left eye did not.

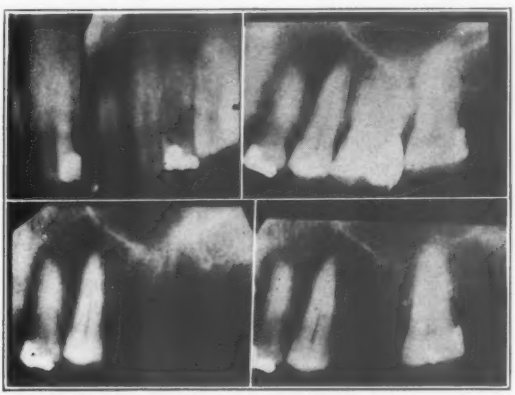

Fig. 6. (Case 4).—Left maxillary region before and after extraction; showing normal structures.

Because of their condition, it was decided to remove the anterior teeth in the upper jaw, and they were removed July 8. A report from the oculist, August 11, stated that while the removal of the teeth had improved the eye condition, the teeth evidently were not the sole cause of the condition. A report September 2 was still more favorable as to the eye condition.

CASE 6.—W. B., a man, aged 50, seen January 16, 1940, complained of neuritis in the left forearm.

I had considered the right maxillary sec-

ond molar a potential source of infection for several years, but, in spite of a near exposure of the pulp and deep alveolar atrophy, I could not, in light of its apparently perfect health, condemn the tooth. But now that neuritis had come into the picture, a complete roentgenographic and clinical examination of the mouth was made. Roentgenographically, little change was found and clinically the only change noted was an exceptionally sharp response to ice by the left mandibular second molar, indicating a pulp hyperemia, and possible degenerating changes. The patient was not willing to have the tooth removed and its removal was not urged. However, about two months later, he developed an acute odontalgia and the tooth was removed, with a miraculous cure of the neuritis. Now, eighteen months later, the patient states that the arm is perfectly normal. (Figs. 8 and 9.)

August 6 of this year, the patient again came in, this time with neuritis in the right shoulder. Nothing could be found in the mouth to account for the condition except the right maxillary second molar, which had been under suspicion for several years, as stated above, and which now gave more evidence of pathogenicity than on previous examinations. Its removal was therefore advised. The patient set a day to have it removed, but went on a business trip instead. I did not see him until September 5, when he kept an appointment for his periodical prophylactic treatment. I noticed that the tooth was gone and said, "I didn't know you had had that tooth out." "Well," the patient said, "I'll tell you what happened. My shoulder got so much worse while I was away that I looked up a dentist and had it out." "What did he find?" was my immediate query. "He found you were right. He cracked the tooth open and the nerve was bad. And I have found that you were right, too. My shoulder is entirely well."

CASE 7.—Mrs. P. D., aged 47, seen in July 1941, had been operated on in March 1940 for a cracked patella of the right knee and a bunion on the left foot, but had not made a satisfactory recovery. The teeth were roentgenographed in the hospital and pronounced normal, but shortly thereafter a periapical abscess developed on the maxillary left second bicuspid. The tonsils were of the buried type, but were pronounced negative. However, upon the patient's insistence and against the operator's advice and wishes, the tonsils were removed, and they were found to be badly infected. The patient then started to improve and, from being bedfast, could now walk with crutches. After the experience with the tooth that abscessed and with the tonsils, it was decided to make another oral examination. The mandibular

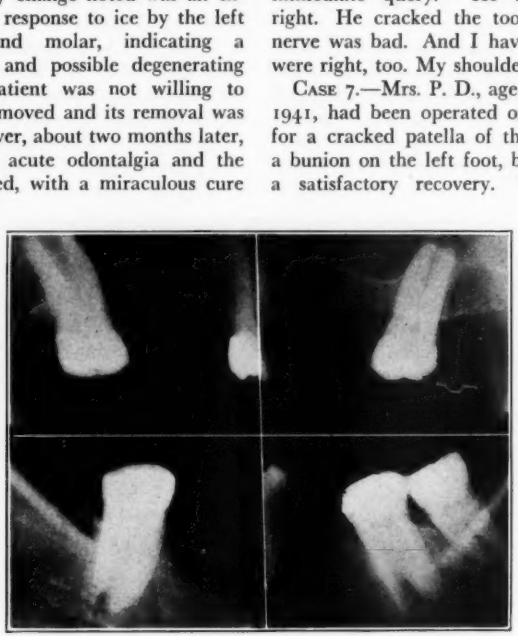

Fig. 7 (Case 5).—Molar teeth which proved to have pathologic pulps although they seemed to be normal.

left first molar, though normal in all clinical examinations, showed definite changes periapically in the roentgenogram. It was removed, and when it was cracked open, the pulp was found to be diseased.

The patient reported, October 4, with so much improvement that she had discarded her crutches. She stated that since improvement dated from the removal of the molars above referred to, she believed that it was the final offender. And indeed it might have been the last focus of a series of foci.

CASE 8.—Miss R. F., aged 57, seen July 1941, had had a normal response of all the teeth to vitality tests, but in response to a question as to her general health, said, "Much worse than three years ago. I've been in bed most of the past year. My heart is worse, colitis is worse and arthritis no better."

This report referred to one made three years previously and was amplified by the statement that her teeth were sore to bite on, especially those of the lower jaw.

Shortly thereafter, she complained so insistently of the mandibular right second bicuspid that it was extracted, and when it was cracked open, the pulp was found to have liquefied.

A replacement was made for the mandible, supplying the missing teeth on the right side and some others. (Fig. 11.) During the work, the patient kept complaining of the maxillary left second bicuspid, which was finally removed and the pulp cultured, with the following report: "Brain broth showed a pure culture of long chain, nonhemolytic streptococcus."

After the removal of the mandibular teeth, there was a decided amelioration of symptoms. A vaccine was made from the culture of the maxillary bicuspid and the first injection resulted in a marked intensification of all symptoms.

During the early part of August, the patient complained of the left maxillary first molar. This was removed August 26, and the pulp was found devoid of circulation because of interstitial calcification.

A report from the patient September 2 was to the effect that she experienced a much more severe reaction to the removal of the molar than in the case of either one of the two bicuspids or the injections of the vaccine.

September 8, the patient complained of continued pain, involving the left ear and cheek and temporomandibular joint. An examination of the paranasal sinuses on this date was negative.

The remaining teeth, particularly in the upper jaw, are sore and painful and their removal is contemplated because of the

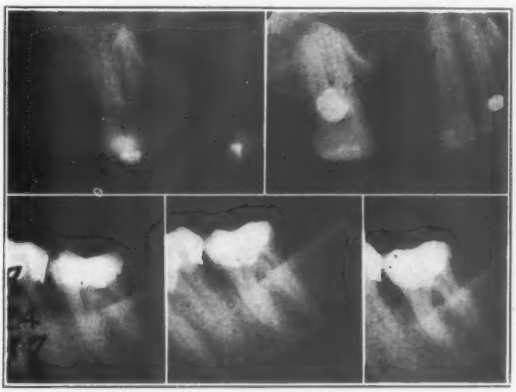

Fig. 8 (Case 6).—Below: Mandibular left second molar, August 27, 1937, January 16, 1940 and April 4, 1940, when it was removed. Above: The right maxillary second molar is shown as it appeared August 24, 1937 and August 6, 1941, shortly before it was removed.

symptoms and the findings in the teeth that have been removed, as well as because of the insistence of the patient that they be removed. Because of the similarity of many of the symptoms in this case to those of the two cases in which a high nonprotein nitrogen was disclosed, a blood chemistry examination was made September 23. The report, however, was contrariwise, as the nonprotein nitrogen was 25.5 mg. per hundred cubic centimeters of blood, which is normal.

CASE 9.—Mrs. J. S., aged 52, had a complete roentgenographic examination August 10, 1939. Vitality tests elicited a hypersensitive response from all the teeth and there appeared to be no difference in the response from the three teeth shown in Figure 12 and those of the rest of the mouth. The

Fig. 9 (Case 6).—Right mandibular second molar, which was removed December 7, 1941, and which was found to have necrotic pulp.

widening of the peridental space in the apical region of both bicuspids and particularly of the second bicuspid was noted, as well as thickening of the *lamina dura*. In the absence of subjective symptoms, and with no evidence of occlusal trauma, the hypersensitiveness was not considered pathologic.

April 7, 1941, the patient complained of toothache in this region. The roentgenogram (Fig. 12) showed no particular change, but, on test with electricity, the first bicuspid responded on the second step of the control, whereas the second bicuspid did not respond until the ninth step. The second bicuspid was sore on percussion and it was therefore removed. The pulp was almost non-existent and there was no sign of circulation therein.

The fact that this tooth had a large filling, which had been in place many years, accounts in some measure for the degeneration of the pulp. In some of the previously recorded cases, the teeth had not been filled or had only small fillings.

CASE 10.—A. D., a dentist, aged 36, had had much pain and discomfort in his right arm for more than a year, and at the same time he experienced discomfort in the mandibular molars, particularly on the right side.

A roentgenogram of the right mandibular molars was made May 19, 1941, and, upon test with ice, the shock was acute. (Fig. 13.)

In consideration of the hyperemia and calcification of the pulps, these molars were removed, June 10. They were cultured and the following report was made by the bacteriologist: "Two large pulp stones. One pulp stone had no growth. The second showed a growth of non-hemolytic streptococcus and staphylococcus."

June 22, the patient reported complete relief from discomfort in the arm, but in a letter August 21, he said, "My arm for the past month has been quite bad. I had an x-ray taken of it which shows a spur on the styloid process of the ulna."

The removal of the teeth in this case may have been a mistake although the relief experienced the first month points to the possibility of the trouble in the arm having been, in part at least, sequential to infection. A complete roentgenographic examination might disclose other foci of infection which might have some relation to the trouble.

CASE 11.—Mrs. E. G., aged 47, had complained of arthritis in her hands for two or three years. Finally, because of the periapical sclerosis of the right mandibular first molar, the tooth was removed in 1940. There was no marked beneficial change. (Fig. 14.)

Early in the spring of 1941, the patient complained of discomfort in the left maxillary first molar. Vitality tests and percussion of this tooth gave negative results. A roentgenogram of the tooth taken at this time was also negative, and interpretation was not different from that of previous years. However, two months and a half after the last exposure and tests were made, an acute odontalgia developed. The tooth was re-

moved and the pulp was found to be putrescent. The history would indicate that the pulp in this tooth had been diseased for some time in spite of the negative clinical and roentgenographic findings. Whether it was the cause of the arthritis in the hands is not yet known, and, naturally, may never be known.

ADDENDUM

CASE 6.—This case has had such an interesting aftermath that I am including this additional history as part of the original case history.

November 27, 1941, the patient developed an acute inflammation of the right eye. The internist thought that it was due to overwork and an approaching nervous breakdown, and sent him to the hospital for rest and treatment. The eye not only did not improve under this treatment and local applications, but grew worse. Finally, an oculist, called on December 3, pronounced the condition iritis. Sterile milk injections were made, but as the eye grew steadily worse, I was called on the case December 7. Vitality tests were made and the right mandibular second molar failed to respond. And since it had responded normally the previous August, its removal was advised even though there was no roentgenographic change. The tooth was removed December 8, and the eye began to improve within twenty-four hours and made a complete recovery.

Because each of the three teeth which had been removed were apparently normal a short time before their removal and because of the almost instant relief from the painful conditions upon their removal, it was decided to remove the remaining three

Fig. 10 (Case 7).—First molar as it appeared in 1923, 1933 and 1941.

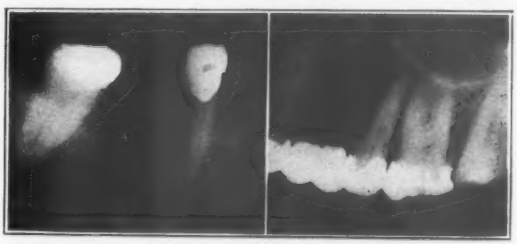

Fig. 11 (Case 8).—Mandibular right bicuspid and maxillary left second bicuspid and first molar, which showed necrotic pulps when opened.

molars as a prophylactic measure. They were removed February 14, 1942, and the pulps were found to be diseased in each one.

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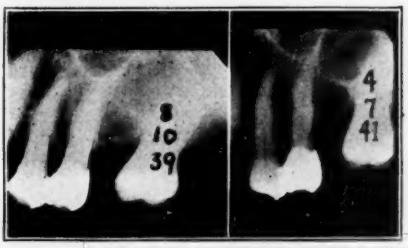

Fig. 12 (Case 9).—Second bicuspid which was hypersensitive in 1939, but hyposensitive in 1941. When it was removed in 1941, the pulp was hairlike.

Fig. 13 (Case 10).—Molar teeth showing extensive calcification of pulps.

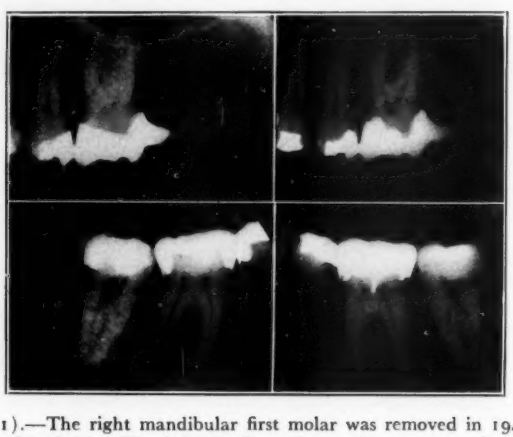

Fig. 14 (Case 11).—The right mandibular first molar was removed in 1940 without noticeable improvement of arthritis. The left maxillary first molar was negative to all tests in the spring of 1941, but the pulp was putrescent two and one-half months later.

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GLANDULAR AND GENERAL SYSTEMIC FACTORS IN THE PROCESS OF DECAY

By T. A. HARDGROVE, D.D.S., Fond du Lac, Wis.

IN a study of the cause, prevention and method of decay of the teeth, endocrine function must be taken into consideration. With a beginning statement that all functions are controlled by the endocrine system, including hormones, dental caries becomes as much an evidence of dysfunction as it is a pathologic change. The endocrine glands have their period of development, establishment and acquired balance. In the beginning, their functions are mixed, and those that perform one function in the early part of life may exchange or transfer that function later.

The functions of these glands are destined to arrive at a normal balance in their relation to each other, and, as a rule, they do arrive at and maintain that balance. This establishment of normal balance may be delayed to a greater degree in some individuals than in others, depending to some extent on hereditary tendencies. For example, under normal conditions and during the early part of life, red blood cells are manufactured by the spleen. Later, this function is taken over by the marrow of the long bones, and, in case the long bone marrow fails, the function returns to the spleen. Thus, it is quite evident that interchange of function is a requirement of nature within this system. The parathyroid and the thymus may exchange functions with the thyroid and pituitary during the early part of their development. In this complicated system, the parathyroid may be a trifle more complicated than the other endocrine glands.

Sevringhaus, of the University of Wisconsin, says, "There is still doubt as to the existence of a factor from the anterior pituitary which controls parathyroid activity, and that secretions from the parathyroid are known only in impure form, but that extracts of the macerated glands have the ability to elevate total serum calcium and depress serum inorganic phosphorus concentrations." When calcium goes above the normal level, there is a depression of the phosphorus level, and so they become factors in the development, preservation and maintenance of the bone and tooth structure. If the gland were macerated and an extract made from it, it might be possible to use the extract to elevate the total calcium. It is well known to investigators that a deficiency of parathyroid function is followed by an abnormally low calcium function; so that with a deficiency in the parathyroid gland, disintegration of bone and tooth structure,

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with a high phosphorus concentration, can be expected. In opposition to that function, an overstimulation or overactivity of the parathyroid will lead to fixation of calcium from bones. In an abnormally high serum content or metastatic calcium content, a metastatic calcium deposition is apt to take place in soft tissues, with what is known as a calcinosis and the formation of kidney stones and like deposits, which may be the beginning of what is commonly known as pyorrhea. Therefore, the calcium combinations must be prescribed with caution and the patient must be under observation during the period of administration. If the patient reacts very quickly, calcinosis and some injury may result; therefore, it is a good idea to prescribe calcium for ten days, then withhold it for twelve days, alternating until the desired result is obtained.

Science has not been able to prepare an extract or a secretion from the parathyroid gland that is safe for experimental use for the prevention of bone changes and tooth decay in the human subject. Sevringhaus says:

> The exact chemical and physiologic mechanism involved in the control of minerals by the parathyroid is as yet unknown. But that there is a physiological and chemical mechanism that is going to require further study is very evident. . . . One of the simplest ways to view the parathyroid functions is to consider the primary activity of the hormones as facilitating excretion of inorganic phosphorus by the kidneys.

With a high serum phosphorus, there is a decreased excretion of phosphorus in the urine. Since feeding sugar will sometimes diminish the high serum phosphorus without changing the calcium level, the sugar in the blood stream itself may not be responsible for decay. At least, it is going to require further study to explain how it occurs. It is a dangerous thing to interfere with the normal sugar content, contrary to the general opinion, when dealing with dental caries. Hyperparathyroidism shifts the pH of the blood to the acid side, while the induction of an alkalemia causes tetany. The foregoing method makes it possible to determine the functional activity of the parathyroid gland and hormones, to some extent at least.

Investigators have well established the fact that parathyroid overfunction will lead to depletion of serum phosphorus, with resultant mobilization of phosphorus from the bone reservoirs.

Franklin C. McLean, M.D. and William Bloom, M.D., of Chicago, observed parathyroid extract in transit from the disintegrating trabeculae of spongy bone to the venules of the marrow in an effort to determine its mode of action on bone and bone salts. They studied also the mobilization of calcium salts in puppies following a single dose of parathyroid extract, and they were unable to demonstrate a phagocytic action in connection with the resorption of the organic matrix and inorganic salts of bone. They found that bone salts and bone matrix are resorbed simultaneously, but found no evidence of phagocytic function of osteoclasts. To some extent, the resorption of the organic matrix and inorganic salt that takes place is, they observed, analogous to that which takes place on the surface of the teeth and roots, which we call erosion and with which we have been unable to deal satisfactorily. This too is an endocrine dysfunction and not an infection. This function, in reality, is taking the calcium from bone structure at one point and moving it some other place, a demonstration of the low serum phosphorus and high calcium. Then too, a return to normal function will be followed by an accumulation of serum phosphorus, and a consequent tendency of phosphorus to enter the bone reservoirs, in which case the calcium must also enter, and it demonstrates that, by utilizing the hormones, it may be pos-

sible to arrest or ward off an approaching period of decay. In this process, there will be an elevation of serum phosphorus and depression of serum calcium. "In the first case, bones will become decalcified, and, in the latter case, densely calcified." The white line ordinarily found at the cervices of the teeth during pregnancy and in other situations is evidence of imbalance of function rather than a bacterial manifestation.

This enables us to rationalize the process of dental decalcification, and to understand the relation between phosphorus and calcium in the calcium deposit process. To understand tooth formation, tooth calcification, tooth decalcification and decay, one must understand the action of the parathyroid gland on the bones, because, in the last analysis, the tooth is a bony structure with a dense enamel on the outside for its protection. Any other bone so exposed would decalcify and break down immediately.

Now, the calcium mobilization that results in decalcification in persons who have had hyperparathyroidism for a long time may explain the damage to soft tissue following the persistently low serum phosphorus or other evidence of metabolic disturbance after which calcium is deposited, as it frequently is, at the site of injury; which, in a measure, explains the rapid decay found in old age. The process referred to when immunization takes place in teeth that have previously decalcified and decayed is one that is engineered and supervised by the parathyroid gland and its co-workers.

In families, we frequently find decay in the same areas of the same teeth. The children, particularly the girls, have the same caries experience, many times, as far as incidence is concerned, as their mothers have had; the parathyroid tendencies and function being inherited. The parathyroid hormone is apt to be much the same in each family, and, incidentally, there is apt to be the same type of decay. There is, in a great many cases, a great loss of calcium; or a great deal of fecal calcium may be found in the intestinal tract. This reference is not only to calcium found normally in the gastrointestinal tract, but also to calcium which has been excreted into the gastrointestinal tract. These sources of calcium loss are varied. It can be moved from bone and utilized in a soft tissue metabolism. It can be lost through the gastrointestinal tract. It can be lost by an abnormal creation of parathyroid hormones, which causes calcinosis.

From the point of view of well-formed, strong teeth, and from the dental point of view, it is necessary that these processes be arrested as early as possible to protect the bones and teeth from deformity and decay. I am referring particularly to the expectant mother and the developing child. Calcium intake is fortified by oral use of chloride, lactate or gluconate. It is said by investigators that calcium prescriptions are efficient in the above named order. In my own experience, the calcium lactate is the most practical, but it must not be given for too long a period at a time, because of the danger of depressing the phosphorus level and creating an imbalance. Maintenance of a normal, harmonious relation of the parathyroid gland to the other glands and to the phosphorus and calcium levels that it controls assures progress toward prevention of decay of the teeth.

When calcium salts are administered, it is advisable to give large quantities of water, because these salts are more effective if entirely dissolved rather than in tablet form, for the reason that loss of calcium in the gastrointestinal tract will be decreased. The same measures are indicated when beginning decalcification of the teeth is noted. It is easier to correct then than after it is well established. In beginning decay, it is possible to ini-

tiate or increase the production of hormones. Dihydrotachysterol is a substitute for parathyroid hormones. It is not advisable to use it promiscuously because it is used in tetany, caused by a disturbance of the parathyroid gland, and tetany is a much more serious condition than beginning decay. It has been shown by Althausen, Kerr and Stockholm that certain thyroid disturbances can interfere with normal calcium metabolism by a negative effect upon the parathyroid gland.

This is a situation where iodine or calcium iodide should be used as a means of combating decay of the teeth, since iodine will, many times, correct that function of the thyroid, and the normal thyroid will not negative the function of the parathyroid gland. It is also the point where most patients who have had thyroid operations should be watched and should be given some form of iodine for the regulation of the thyroid and parathyroid. It is well established that temporary periods of tooth decay are apt to follow a thyroid operation. Some of the diseases that occur in hyperparathyroidism include osteitis fibrosa cystica, diffuse osteoporosis of certain types, renal calcinosis, or recurrent stone in the urinary tract, and metastatic calcification. They may be prevented or ameliorated by giving compound solution of iodine (Lugol's) daily, and large doses seem to do no harm. It is wise to prescribe vitamins A, B, C and D, and fruits and vegetables that contain them. In some instances, 10 mg. of sodium iodide is indicated, to arrest decay. The administration of small doses of iodine, 1 to 10 minims a week, to children, has a balancing effect on the parathyroid hormones and thereby assures a balance of calcium and phosphorus in the bones and teeth, and incidentally reduces the incidence of decay.

The greatest endocrine influence on the parathyroid gland should be exercised while the child is very young or before the child is born. Early establishment of parathyroid balance is apt to result in good bone and tooth formation. All other efforts that have been made for the prevention of decay in children and adults have been a failure. Teeth that show no resistance to decay are hungry for calcium and phosphorus in the proper proportions. One of the chief disturbances of calcium balance is pregnancy and lactation. Calcium should be administered to the pregnant woman for the construction of the teeth of her child and to fortify her own teeth. A normal hormone relation is necessary during pregnancy, and the normal hormone relation is dependent on the normal endocrine mechanism. The endocrine mechanism during pregnancy is severely taxed, particularly if the balance of the endocrines is inclined to be unstable. There are mothers whose endocrine balance is not disturbed greatly during pregnancy, but, as a rule, they have inherited a stable endocrine mechanism and endocrine balance. The child that is nursed by a mother with a normal endocrine balance is indeed fortunate because the mother's milk has in it that, call it vitamins or whatever you choose, which promotes in the child the normal hormone relation.

Price, in his investigations, has shown that, to a large extent, primitive people have good teeth and well-formed jaws; which means to the investigator that they have inherited a well-regulated endocrine system owing to the fact that they are not a mixed race, and their endocrine system is more likely to be normal and harmonious.

If each race were kept absolutely pure, the incidence of decay of the teeth would not be so great. Of course, bacterial influence plays a part in the process of decay, but it is the secondary stage in the process of decay. We cannot get away from it in decay of the teeth any

more than we can in the case of cancer or any other disease. Cancer becomes mixed with other infections, and tissue breaks down more readily, just as tooth decay occurs as a result of dysfunction first and bacterial invasion for the completion of the process that we know as dental caries. The more nearly normal the endocrine influence, the more nearly normal will be the formation of the tooth, and the more likely it is to be free from the pits and fissures that invite decay.

The problem of decay will not be finally solved after a short effort, but after more profound study of the endocrines in their relation to and influence on the tissues of the body, with special reference to calcification, decalcification and the hormones that have to do with bones and teeth and other tissues in the oral cavity, including the saliva, secretions and excretions.

CONCLUSIONS

A study of dental caries includes a study of both development and maintenance of bones and teeth in their relation to the endocrine glands and particularly the parathyroid, thyroid, pituitary and thymus glands.

All of the phenomena of tooth decay, including resorption and erosion of the surface of crowns and roots, are endocrine manifestations.

The time to build good teeth for the child is the time of formation of the tissues.

Control of the endocrine glands during pregnancy and in the early part of child life is essential. Calcium, iodine and vitamins A, B, C and D, and the extract of the parathyroid, when it can be safely used, are the medical means of immediate arrest and prevention of decay.

Better teeth will be produced after several generations than can be produced in the immediate one.

We inherit our tendencies to dental decay because we inherit the endocrine mechanism to a large extent.

The unmixed races, particularly the Latin races and the primitive ones, show a tendency to greater stabilization of calcium and the endocrine system. Teeth that show rapid decay are hungry for calcium and phosphorus in the proper relation.

In prescribing these drugs, care should be exercised not to stimulate the parathyroid gland to too great a production of hormones, for we would be liable to do the very thing we are trying to avoid.

The precipitation of large calcific deposits from the saliva upon the teeth is induced by chemical reactions initiated by the endocrine glands. Serumal calcium, so-called, is a direct evidence of calcinosis or a deposit of calcium in the paradental membrane, which may result in pyorrhea. The profession has known that people with pyorrhea may have less dental decay than those who do not have pyorrhea. The reason is evident.

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CYSTIC TUMORS OF THE NECK: BRANCHIAL AND THYROGLOSSAL CYSTS

By Raymond W. McNealy,* M.D., Chicago, Ill.

THE basic sciences of anatomy, biochemistry, physiology, bacteriology and pathology form the fund of common knowledge upon which both dentistry and medicine are founded. Both the dentist and the physician or surgeon approach the human being as an individualized person and with the definite aim of restoring the organism as a whole to unimpaired activity.

It has been pointed out by thoughtful dentists that the masticating organ has more than a single function involving only the teeth and jaws; in fact, that it has functions involving the lips, muscles of mastication, tongue, nasal passages, palate and mucous membranes of the mouth and throat.

With these truths in mind, it was felt that a discussion of surgical problems arising from certain cystic tumors of the neck would be of especial interest to this group, since the dental surgeon is particularly concerned with the structures involved by these lesions and their treatment. Most physicians and dentists are familiar with the problems which arise from the thyroid gland conditions. They are, however, much less familiar with certain tumors, cysts and fistulae of the neck which are occasionally seen, especially in children.

Lateral and median cysts of congenital origin occurring in the necks of children especially present some of the most confusing problems of diagnosis and treatment which the surgeon is called upon to solve. Further confusion frequently arises from the tendency of these cystic swellings to form sinuses and fistulae.

The classification of these cysts and fistulae on the basis of their nature and genesis has undergone many changes as the result of continued investigation of embryologic formations and exhaustive histologic study. Considerable differences of opinion, particularly in regard to the origin of lateral cysts and fistulae, are still to be found in the literature.

We must recognize that these cystic swellings may originate from many different tissues and that, in many instances, their exact classification can be made only after a microscopic study of the cyst wall and its contents. It may be helpful also to examine histologically the structures adherent or adjacent to the cyst or fistula, since these may give a clue to the nature of the contiguous tissues.

THE EMBRYOLOGIC DEVELOPMENT OF LATERAL CYSTS AND FISTULAE

Various descriptive names have been applied to lateral cystic tumors. The term "branchial cysts" has been used most commonly perhaps. The word "branchial" is of Greek origin ($\beta\rho\alpha\gamma\chi\iota\alpha$), meaning gills. There has been some tendency of late to question the use of the term "branchial cysts" except in describing those cysts occurring above the level of the hyoid bone.[1] While there

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is much merit in this critical analysis of the true embryologic origin, it seems that one might use the term "branchiogenetic cysts," assuming that, in the broad sense, this would designate the general site of origin.

In order to present the subject understandingly, it becomes necessary to review briefly the embryology of the branchial apparatus. The pharynx represents the most anterior part of the archenteron, in which the branchial arches develop. Between the various branchial arches, grooves occur, representing the endodermal portions of the grooves which separate the arches. (Fig. 1a.) It is agreed by most investigators that the arches and clefts give rise to the following structures:

First arch, lateral portion of the upper lip, upper jaw, lower lip, lower jaw and body of the tongue.

Second arch, body of the hyoid bone, stylohyoid ligament and muscle, anterior portion of the base of the tongue and *arcus glossopalatinus.*

Third arch, greater cornu of the hyoid bone, posterior portion of the base of the tongue and *arcus pharyngopalatinus.*

Fourth, fifth and sixth arches, development of the soft parts in the region of the greater cornu of the hyoid bone.

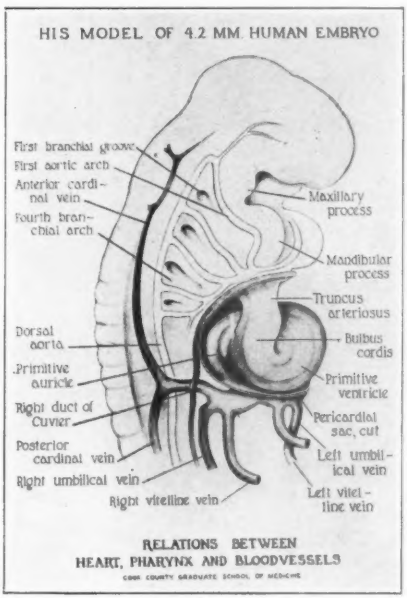
First cleft, external auditory canal and ear lobe.

Second cleft, tonsillar fossa.

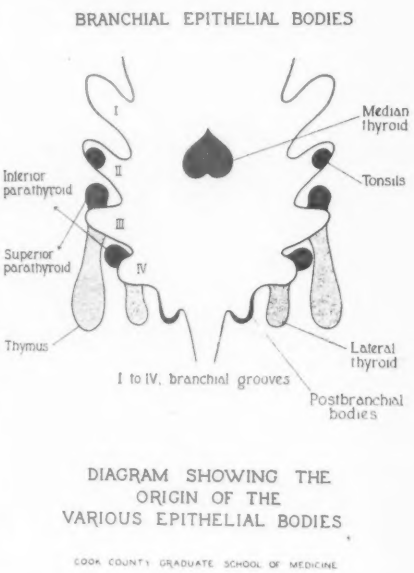
Third cleft, thymus.

Fourth cleft, lateral lobes of the thyroid. (See Fig. 1b.)

The contributions of Wenglowski[2] on the embryology of the area in question, although still a controversial issue, are of great interest. As a result of extensive research on human embryos, he concluded that the branchial apparatus cannot leave remnants in the neck below the level of the hyoid bone. The so-called



A



B

Fig. 1.—A, branchial grooves and arches in human embryo. B, origin of various epithelial bodies.

"branchial" fistula below the level of the hyoid bone is regarded by him as a persistent thymic strand which originates from the third pharyngeal pouch, whence it pursues a long oblique course down the neck to reach the anterior superior mediastinum.

PATHOLOGY

These strands, which may retain their embryologic tendency to vacuolation and canalization, may give rise to lateral cysts or fistulae. Cysts and fistulae may occur anywhere along their tracts, although the cysts are most commonly found in the upper third of the neck. Fistulae may be present at birth or they may break through as a result of infection in the cyst. They may be complete or incomplete. When incomplete, they may open above internally in the posterior tonsillar fossa, while below they almost constantly open externally along the anterior border of the sternocleidomastoid muscle near the clavicle. When complete, a rather uncommon occurrence, the fistulous tract travels a fairly constant course. From its inner opening in the tonsillar fossa, it passes under the angle of the jaw, and thence downward and outward under the midportion of the posterior belly of the digastric muscle, passing below the facial and above the glossopharyngeal nerve to come into intimate relationship with the sheath of the carotid artery and the jugular vein.

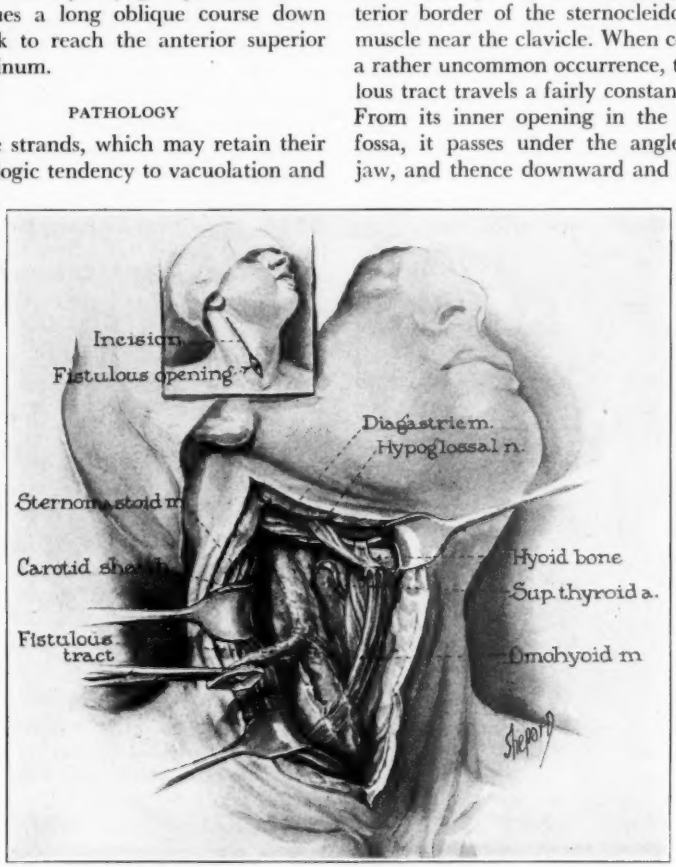


Fig. 2.—Location of incision; fistulous opening encircled and dissection of tract toward its internal opening being completed. The intimate relation of the fistulous tract with the carotid sheath is clearly shown.

This constancy of relationship with the large cervical vessels was strongly

stressed by Senn.[3] Failure to keep this in mind has been the cause of panic and disaster in many operations for the removal of these cystic tumors or their vestigial relatives, the lateral fistulae. (Fig. 2.)

The lowest opening of the lateral fistula is probably determined by the constriction of the canal by the bony opening of the chest, which favors the breaking through of the usually infected contents at this level. The walls of these fistulae are often greatly changed by infection. Histologic investigation of these fistulae and cysts has shown their similarity to the histologic elements of the thymus anlage. One commonly finds areas showing either stratified or squamous epithelium. (Fig. 3.) The walls may contain encysted muscle fibers, cartilage and mucous glands. Much lymphoid tissue is commonly present. Leucine, tyrosine, cholesterol, myelin, palmitin and stearin have been found in the aspirated contents of these cysts.

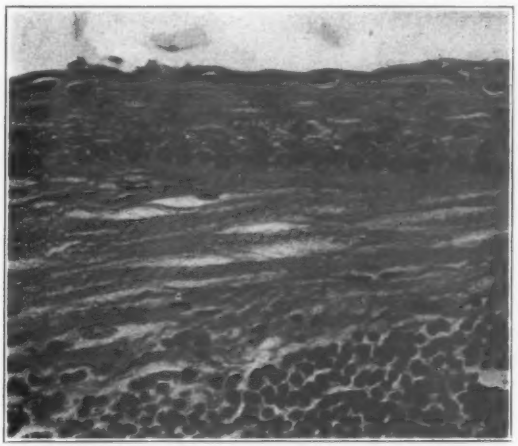


Fig. 3.—High-power view of wall of lateral cyst of neck; showing young squamous epithelium lining and lymphoid tissue in cyst wall.

SYMPTOMS

The clinical picture of these cystic tumors is that of a swelling on the side of the neck, usually causing no symptoms unless it reaches such a size as to press on other structures, when there may be hoarseness, coughing, dyspnea and dysphagia. (Fig. 4.) Pain and tenderness are not common unless there is infection. Fistulae may be present at birth or a cyst may become a fistula when it ruptures spontaneously or is incised. Repeated secondary infection may take place, in which case there are chronic induration and a purulent discharge. The cyst may vary in size with the periodic drainage, and in elasticity according to the amount of fluid it contains and the degree of pressure under which it is held. In most reported series, fistulae have been twice as common as cysts.

DIFFERENTIAL DIAGNOSIS

The correct diagnosis of a lateral cyst is very important if one is contemplating operative removal of a tumor mass in the angle formed by the anterior border of the sternocleidomastoid muscle and the lower border of the inferior maxilla. The close proximity of these cysts to im-

portant structures in the neck makes it imperative that the operator be acquainted with the hazard accompanying their removal. In many instances, a direct diagnosis is made by exclusion of all other forms of tumors.

1. *Carotid Body Tumors.*—These are usually solid tumors which are constant in their location in the bifurcation of the common carotid artery. They are probably related to the carotid sinus. Seventy per cent develop after middle life (40 to 70 years). They are very slow of growth, as a rule, and are freely movable from side to side, but fixed to the carotid artery so as to prevent movement in the line of vessels. Such tumors are nearly always unilateral. They are painless and not attached to the skin. They may be compressed easily, and a bruit and thrill, as well as distinct pulsation, may cause them to resemble an aneurysm.

2. *Tuberculous Lymph Glands.*—It is seldom that one meets a case in which extensive pathologic change is confined to the body of a single lymphatic gland. Confusion most often arises when a small group of fused glands have broken down and are semifluctuant. In tuberculous glands, the skin early becomes dusky red and is commonly fixed to the tumor mass. Carp and Stout[4] state that an x-ray examination should be made of suspected cysts and that calcification is suggestive of a tuberculous gland.

3. *Cold Abscesses.*—These abscesses may arise from burrowing of pus along the fascial planes of the neck, and usually

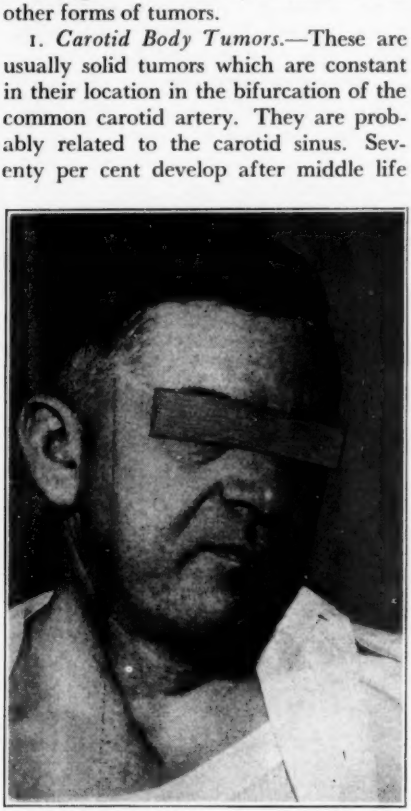


Fig. 4.—Author's patient who had branchial fistula which drained externally and into pharynx. The pharyngeal exudate produced a chronic laryngitis and thickening of the vocal cords and a fluctuating hoarseness.

Fig. 5.—Low-power view of thyroglossal cyst; showing squamous epithelial lining of cyst wall. In the upper right-hand corner is thyroid tissue, a remnant of the thyroid anlage which pulled the oropharyngeal squamous epithelial lining down with it to the base of the tongue.

originate in tuberculous disease of the cervical vertebrae. They may present a lateral cystic swelling in the neck. Aspiration and animal inoculation may be performed in making a differential diagnosis.

4. *Aneurysms.*—The presence of a distinct transmitted pulsation from the carotid vessels may sometimes be confusing in lateral cysts, leading to a diagnosis of aneurysm. It must be borne in mind that the pulsations are never expansile in lateral cysts, and bruits over them are quite uncommon. Pressure on the carotid artery below the suspected tumor does not affect its size if it is an aneurysm. Careful aspiration with a fine hypodermic needle is permissible even when one suspects an aneurysm. Branchiogenetic cysts are most common in children, in whom aneurysms are exceedingly rare.

5. *Dermoid Cysts.*—These are commonly attached to the skin and, on aspiration, the contents show the presence of products of the secretion of the skin and organs which it contains, hair follicles and sweat and sebaceous glands. The wall of a dermoid cyst will show lanuginous hair and hair follicles, which are never present in branchiogenetic cysts.

6. *Angiomas.*—These are common in children and are usually present from birth. They are easily compressible and rapidly refill on release of pressure. This fact usually serves to differentiate them from branchiogenetic cysts.

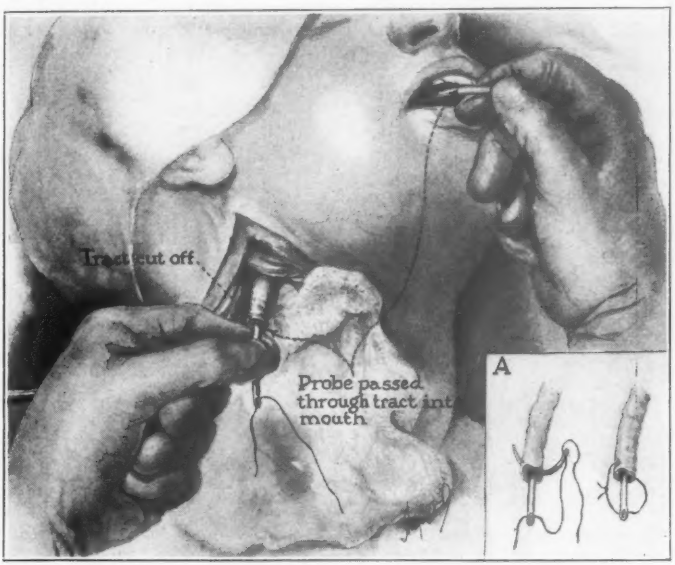


Fig. 6.—Diagrammatic drawing showing passage of probe through fistulous tract into mouth according to method of von Hacker. A, manner of attaching probe to distal end of fistulous tract.

7. *Cystic Hygromas of the Neck.*—These are commonly noted at birth as soft, elastic swellings, which may be unilocular or multilocular. They may be large at birth or their increase may follow irritation, infection or intercurrent disease. Aspiration before infection usually reveals a thin serous fluid, which may contain endothelial cells. Histologic examination of the cyst wall will reveal

the endothelial character of its lining.

8. *Aberrant Thyroids.*—Cysts arising from aberrant thyroid rests can be differentiated only by histologic examination.

MEDIAN CYSTS AND FISTULAE

Median cysts and fistulae are more easily understood on the basis of our present knowledge than the lateral cystic tumors. Three types of midline cysts occur. These may best be described by reviewing the embryologic development with which they are associated as vestigial defects.

The branchial epithelial bodies arise either from thickening or outpouching of the epithelium lining the lower portion of the inner branchial furrows. There are usually five paired bodies and a single unpaired median body. (Fig. 1 b.) The unpaired median body makes its appearance in embryos of about 3 mm., and gives rise to the major portion of the thyroid body. It is situated immediately behind the anterior portion of the tongue, at the apex of a groove between this and the posterior portion. It begins as a pouchlike depression, which deepens and becomes bilobed. After the embryo has reached 6 mm., the unpaired median body is usually completely separated from the floor of the pharynx, but its original site remains marked by a slitlike or circular depression, the foramen cecum. This bilobed body, the anlage of the pyramidal lobe, isthmus and larger part of the lateral lobes of the thyroid, migrates down the neck to its adult location in front and to each side of the trachea and larynx. In its descent, the midthyroid anlage drags on the epithelium of the floor of the pharynx and evaginates it. This evaginated area is lined with squamous or ciliated epithelium and is often branched. (Fig. 5.) It may possess a lumen. The canal that is formed is called the lingual duct. In older embryos and in adults, portions of this evaginated epithelium may give rise to tissue rests or cysts, which comprise the first type of median cysts. These may occur anywhere from the foramen cecum down to the hyoid bone. They are most common in the base of the tongue.

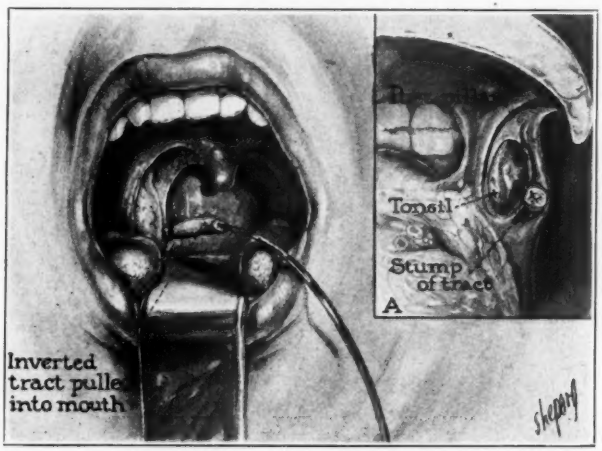


Fig. 7.—Diagrammatic illustration of fistulous tract drawn into mouth and ligated. A, excess portion of tract cut away.

The second type begins with the true thyroglossal strand tissue, commonly referred to as the thyroglossal duct. At no stage of development, however, does

it have a lumen. A vacuolation of this anlage of the thyroid may cause cysts between the tip of the lingual duct and the hyoid bone. At the level of the hyoid bone, the thyroglossal strand is usually difficult to isolate because of its intimate relationship with the development of the hyoid. The hyoid bone begins to develop in the fifth week of embryonic

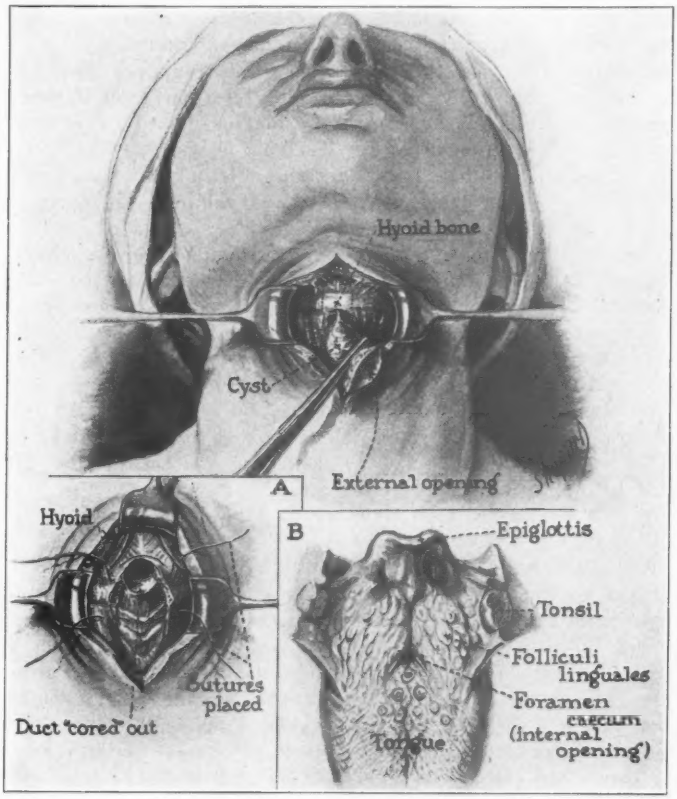


Fig. 8.—Above, dissection of fistula, cyst and portion of hyoid bone to which tract is attached. A, after excision of hyoid. The tract is cored out and sutures are applied above and below the hyoid bone. B, location of foramen cecum.

life. The cells of this bone develop dorsally from the already existing thyroid strand and the two become intimately related. Further growth of the hyoid and its rotation to assume its adult position cause the strand now fused with the

periosteum of the anterior surface to be compressed and drawn posteriorly. The continuity of the thyroid strand is thus definitely broken.

The third type of median cyst is made up of those derived from the midthyroid strand below the level of the hyoid bone. Here, the primitive strand gradually takes on the more definitive character of the

isthmus of the thyroid as it widens out to become the pyramidal lobe. It is in this region that the majority of cysts develop. Failure of the precursor of the thyroglossal strand to descend may result in the development of thyroid tissue at

the base of the tongue near the site of the usual foramen cecum. The removal of such tumors has led to myxedema in some instances, especially when the tissue removed seemed to represent the functionating portion, if not all, of the thyroid gland. Grace and Weeks,[5] in 1932, stated that there have been approximately 130 such cases reported in the literature. Hickman,[6] in 1869, reported the death of a 16-hour-old infant from asphyxiation caused by a goiter at the base of the tongue. Dore,[7] in analyzing eighty-one cases of lingual thyroid, reports myxedema in seven following surgical removal of a lingual tumor. Grace and Weeks call attention to the fact that lingual thyroids are eight times more common in women than in men. They also point out that symptoms develop more frequently at the age of puberty, although several cases in the new-born have been reported. Gross and Connerley[8] have suggested that when such a tumor is found and there is no thyroid palpable, perhaps an incision should be made to determine whether any gland is present in the normal location.

As stated before, the median thyroglossal cysts and fistulae are most common in the midline at or just below the level of the hyoid bone. They may, however, occur anywhere from the base of the tongue to the episternal notch. The cysts are slow growing as a rule and rarely reach the size attained by the lateral cysts. Owing to the location on the anterior surface of the neck, they are subject to constant irritation by clothing and collar bands and often become inflamed and infected. When these cysts break through the skin surface as a result of such irritation, infection or trauma, they present a smooth, shiny lining, which discharges a glairy, mucoid secretion, often mixed with inflammatory exudate. The median fistulae arising from the discharge of the cyst contents on the skin surface are never complete; that is, they can never be traced uninterruptedly to the foramen cecum. Those cysts in the midline above the hyoid bone may discharge on the dorsal surface of the tongue near its base. After the cysts discharge their contents, the site of discharge may remain as a fistula for a varying length of time. Then the opening may close and gradual reaccumulation occur. Such repetition of filling and emptying is characteristic of these cysts, which are most commonly confused with the following conditions:

(a) Sebaceous cysts: One may be misled by sebaceous cysts if they occur in the midline, but the character of their contents leaves little doubt as to their nature. Histologic examination of the cyst wall will reveal their primary dermal origin.

(b) Ranula: Simple sublingual cysts usually elevate the tongue and are translucent. They are commonly confined to the bursae in the loose tissue of the floor of the mouth. It is possible that some of the expansive types may be derived from distention of the epithelial cysts, which are carried from the base of the tongue with the descent of the thyroglossal strand.

TREATMENT

It may be stated that nearly all of these congenital cysts and fistulae may become troublesome, most often from infection, and cases in which they have been the seat of malignant growth are on record. Nothing short of complete eradication of the walls of the cysts and complete extirpation of the epithelial tracts of the fistulae can be considered as adequate treatment.

Lateral Cysts.—In these cysts, one must be familiar with the difficulties of dissecting in the triangles of the neck, and must be skilful in the management of injuries of the large vessels in this locality. It is especially important to know that these cysts are often so intimately attached to the internal jugular vein that, in some instances, they may

require the sacrifice of a part of the vein wall or even the extirpation of a segment of the vein. (Fig. 2.) It must also be borne in mind that aspiration of air following injury of the large veins of the neck may become a serious problem.

I believe that it is the common practice of most operators to dissect the neck with the head and shoulders elevated above the general body level. This position, while advantageous to the operator, favors the development of air-block in the cerebral circulation, which may terminate fatally if the block is extensive or exists for any length of time. The elevated position of the head and neck lessens the congestion of the veins in the neck dissection, but it is probably safer if the surgeon works with the patient's head slightly lower than the general body level. This position is more favorable because of the disposition which the circulation makes of air aspirated through an injury to one of the large veins. Instead of being carried to the important centers within the cranium, the aspirated air finds its level in the extremities, where little damage occurs and where its absorption takes place uneventfully. A further advantage in the head-low position is found in the distention of the readily collapsible veins by gravity. They become more easily recognizable and are thereby less often injured accidentally. This head-low position likewise favors the drainage of mucus and pulmonary secretions.

Lateral Fistulae.—It is important, in these conditions, to establish the tract of the fistula before operation, if this can be done. Many ingenious methods have been suggested for following these tracts. I have favored the injection of the tract with a solution of hydrogen peroxide to which a few drops of methylene blue has been added. When this solution is introduced with a blunt-pointed syringe at a very low pressure and comes in contact with the secretions of the tract, the formation of free oxygen, which will distend the tract, is favored. The methylene blue, being carried along by the gas bubbles, will stain the lumen a light blue. The escape of the blue gas bubbles from the pharyngeal opening in the posterior tonsillar fossa can usually be easily seen.

Figure 2 shows the usual incision and the character of the dissection of the lower part of the lateral fistulous tract. The greatest difficulty is encountered about the level of the greater cornu of the hyoid bone, where the fistula passes beneath the posterior belly of the digastric muscle. Blunt dissection at this level is probably the safest procedure. One should exercise care at this point not to injure the hypoglossal, glossopharyngeal or facial nerves. After the tract has been traced beneath the posterior belly of the digastric muscle, it is well to cut off the lower portion of the tract, leaving a small segment of the proximal stump.

Von Hacker[9] suggests passing a probe through the pharyngeal orifice of the fistula at this stage and then along the tract to the distal end of the remaining short stump. A ligature then transfixes the stump and is attached to the probe, which, when withdrawn into the tonsillar fossa, will invaginate the fistulous tract into the posterior tonsillar fossa, where it may be ligated close to its base, and the remaining part be cut off. (Figs. 6 and 7.) Some operators suggest removal of the tonsil on the side of the fistula with dissection of the fistulous tract up to its inner orifice, and finally encircling this orifice, freeing the tract completely. The opening left is then closed with a suture or two. This, to my mind, adds considerable gravity to an already formidable procedure and should be done only in those cases wherein its execution is easy.

Koenig[10] has suggested a method of dealing with the proximal stump when it cannot be invaginated into the pharynx. He recommends drawing the distal end of the short stump into the anterior tonsillar fossa through an ad-

ditional slit opening, followed by fixation of the fistulous tract with a suture. This procedure will bring both openings of the tract within the pharynx and will prevent discharge of the contents of the fistula externally, since the two openings of the epithelial tract will be located on the same side of the pharynx in the tonsillar fossa.

Median Fistulae and Cysts.—These can be traced in the manner suggested for lateral fistulae. If they are well stained with methylene blue, as suggested, their outline can be more easily followed. Most operators favor a transverse incision. While I have had very good results with a vertical incision extending for a short distance from either end of an encircling incision about the fistulous opening or cyst, the transverse incision gives a better cosmetic result. The walls of these median cysts and fistulae may be thickened from recurrent inflammation, but they are often so delicate that only very careful sharp dissection will accomplish their removal without tearing into the cyst or tract of the fistula. The continuity of the cyst wall or fistulous tract is quite easily lost in those walls which have not been thickened by infection.

When the hyoid bone is reached in the dissection of the fistulous tract, it is best to avoid trying to follow the tract beyond this point before dividing the hyoid bone. I have found it much easier to trace the tract to the lower margin of the hyoid bone and then immediately divide the hyoid bone on each side of the attachment of the fistulous tract. (Fig. 8.) After this is done, the tract is pursued upward and backward toward the foramen cecum. My experience has left me in doubt as to the possibility of tracing the tract for any distance beyond the hyoid bone with certainty. I believe that, from the hyoid bone onward, one must rely on simply coring out the tract in the tongue muscles in the general direction of the foramen cecum.

In most instances, it is better to avoid entering the oral cavity. Careful hemostasis should be secured, with no drain inserted in these cases unless oozing is intractable. The fragments of the hyoid bone, which are left after the symphysis has been excised with the tract, may be approximated by a suture above and one below the bone. When these sutures are tied, the ends of the hyoid bone are brought into close proximity, and fibrous union will usually result. After the first few days, no difficulty due to the disposition of the hyoid bone is experienced by these patients. At first, some slight pain may be felt with swallowing movements.

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MICRO-INCINERATION STUDIES OF AN ENAMEL-CONTAINING AMELOBLASTOMA

By EDWARD G. HAMPP,* D.D.S., M.S., Bethesda, Md.

DURING the course of a routine study of ameloblastoma by the method of micro-incineration, a piece of tissue (received from the Department of Pathology, University of Rochester, Rochester, N. Y.) was found to contain an area showing a thin layer of enamel in close proximity to a mesenchymal osteoid-like material. The presence of enamel in the ameloblastoma is infrequent, having been reported on only a few occasions since 1885. Chilbret[1] and Bernay[2] reported enamel alone; D'Aunoy and Zoeller,[3] enamel, dentin and cementum; Mummery and Pitts,[4] a calcified mass, and Ghosh,[5] enamel matrix. By the technic of micro-incineration, it may be possible to supply additional information concerning the histogenesis of such neoplasms.

The method used in the preparation of tissue for incineration is primarily that of Scott[6] and has been described by him in detail. Only the briefest summary of it will be given here. The tissue is fixed in a mixture of absolute alcohol and 10 per cent neutral formalin, dehydrated by passing through a series of changes of absolute alcohol, cleared in xylene, and embedded in paraffin in the usual manner. Sections 5 microns thick are placed on glass slides and flattened by gentle pressure. The tissue is incinerated at 650° C., thirty-five minutes being taken to reach the final temperature. While the slides are still warm and therefore unable to condense moisture from the air, a cover glass is sealed over the preparation by means of a beeswax and paraffin mixture.

The heat-resisting minerals remain, as far as can be demonstrated, in the same topographic relationship as in the fixed tissue. The total heat resisting elements can be recognized by the color of the oxides and carbonates. For example, iron is easily detected by its yellow to red brown oxide. The depth of color is apparently proportional to the amount of iron involved. This finding has been confirmed by the quartz spectograph. Calcium and magnesium carbonates give a characteristic highly refractive white ash, which, with little experience, can be consistently recognized. In striated muscle, this ash has been clearly demonstrated, by the electron microscope in the hands of Scott and Packer, to be calcium and magnesium.[7]

OBSERVATIONS AND COMMENTS

Figure 1 is a photomicrograph of a section of an enamel-forming ameloblastoma, stained with hematoxylin and eosin. A striking similarity can be seen between this structure and a functioning enamel organ. That portion of the section corresponding to the stellate reticulum of an enamel organ contains fine protoplasmic processes extending from one cell to another, resulting in a starlike appearance of the cells. Also within this area are

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found groups of blood spaces. The stratum intermedium-like portion consists of a condensation of four or five cell layers in width with an elongated protoplasmic extension communicating with the processes of the stellate reticulum. The nuclei are slightly elongated and parallel the surface of the adjacent ameloblast-like cells. These tall columnar cells have a striking morphologic similarity to true ameloblasts. The nuclei are in the functional position; i.e., the distal poles of the cells. The proximal ends are in close proximity to a partially calcified substance which has been formed by these cells and is apparently enamel. That portion which is in direct contact with

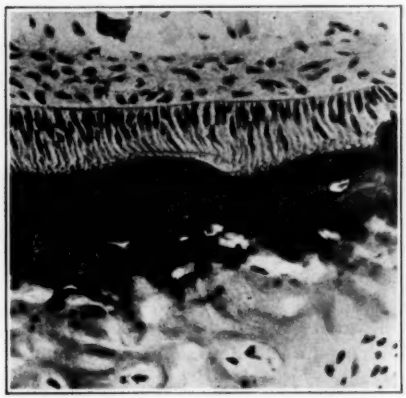

Fig. 1.—Section of enamel-containing ameloblastoma. a, enamel; b, homogeneous osteoid material. (Hematoxylin and eosin; ×350.)

the ameloblast-like cells stains less deeply and is more nearly homogeneous.

In direct contact with the enamel is found a homogeneous eosin-staining osteoid-like mesenchymal tissue exhibiting some degree of calcification. At various intervals, lacunae are found containing mesenchymal cells. This tissue is rich in collagen, as shown by a van Gieson's picro-acid fuchsin stain.

Figure 2 is a photomicrograph of a control section, stained with hematoxylin and eosin, containing a group of prefunctional ameloblast-like cells with the nuclei in a migratory position. The periphery of the nuclei stains a deep blue, whereas the central area contains a lighter blue network of chromatin. The cytoplasm is stained light pink, but, in some areas, is clear and structureless, particularly in the proximal region.

Figure 3 is a corresponding incinerated section. The nuclear membranes do not leave a distinct deposition of mineral. However, the nuclei are rich in the characteristic diffuse white refractile ash of calcium and magnesium which corresponds to the chromatin material in the control section. The particles of ash vary from extremely fine granules to coarse aggregations flecked with brownish red,

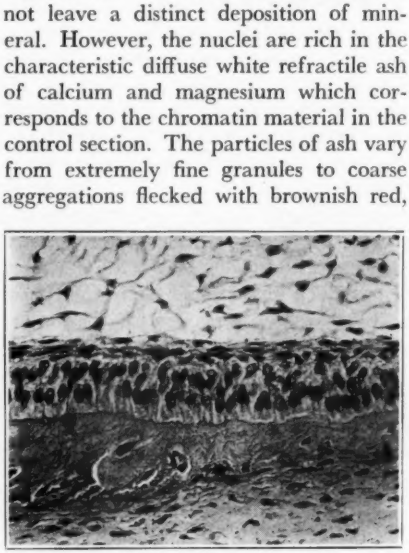

Fig. 2.—Control section of prefunctional ameloblast-like cells. (Hematoxylin and eosin; ×350.)

indicative of iron. The cytoplasm of these cells is practically devoid of mineral; which is in keeping with the differentiating ameloblasts of the true enamel organ as pointed out by the author[8] previously. The cell membranes are discernible, consisting of compact particles of the white ash of calcium and magnesium. In addition to the calcium, magnesium and iron, phosphorus is probably present in considerable quantities, as indicated by the difficulty experienced in obtaining complete incinerated sections.[9]

Figure 4 is a photomicrograph of an

incinerated section containing stellate reticulum-like tissue, an inner stratum and a group of functioning ameloblast-like cells that have been torn away from the enamel.

The stellate cells consist of fine, interlacing protoplasmic extensions that leave a very delicate, but compact ash of calcium and magnesium. The cytoplasmic and nuclear deposits are of the same general character, with the greater concentration of ash in the nuclei. No definite deposits of mineral are present to indicate cell membranes. Scattered in the intercellular spaces are numerous extremely dense globules of highly refractile white ash. The ash of the inner stratum of cells is of the same general character as the stellate reticulum, except that there is a slight bluish hue over the background. The whole picture is in keeping with that of analogous structures of the true enamel organ.[8]

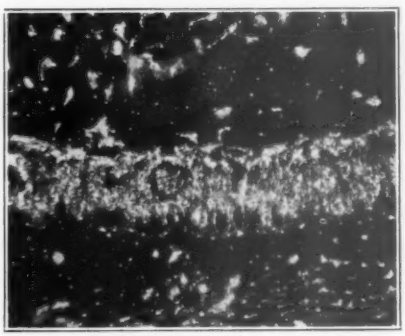

Fig. 3.—Incinerated section of prefunctional ameloblast-like cells. (×350.)

On observing the ameloblast-like cells, the most striking change, as compared with that of the prefunctional predecessors, is the increase in amount of cytoplasmic ash, which is chiefly calcium and magnesium interspersed with a bluish residue suggestive of sodium. The cytoplasmic ash is so abundant that the nuclear deposits blend with it, making differentiation of the cellular constituents very difficult. However, certain levels within the distal part of the cells contain numerous brownish red flecks of iron, and these areas correspond to the positions occupied by the nuclei. At this stage, there is apparently more iron present than in the prefunctional ameloblast-like cells. The distal and proximal boundaries of the cells are discernible, being formed by compact particles of calcium and magnesium. However, the lateral boundaries are obscured by the heavy deposits of cytoplasmic ash.

SUMMARY AND CONCLUSIONS

An ameloblastoma was described which exhibited an area containing a thin layer of enamel deposited in close proximity to partially calcified osteoid-like mesenchymal tissue. From all histologic evidence, the cells comprising the enamel-forming portion of the neoplasm had differentiated similarly to those of the true enamel organ. This was further substantiated by micro-incineration studies. The quantity, quality and distribution of the ash deposits within the individual cellular elements are in keeping with those of the true enamel organ.[8]

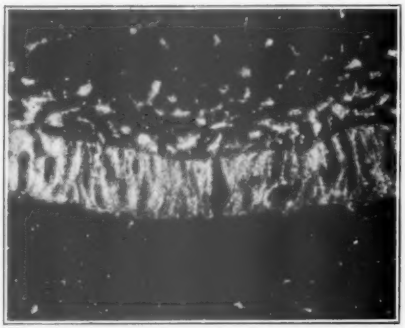

Fig. 4.—Incinerated section containing stellate reticulum-like tissue, inner stratum and group of enamel-forming cells that have been torn away from enamel. (×350.)

Kronfeld[10] has pointed out that ". . . . for the formation of enamel, specialized

mesodermic cells are necessary." It is imperative that a small amount of dentin be deposited before amelogenesis can be initiated. Apparently, the mesenchymal osteoid-like material furnished the stimulus necessary to activate the enamel-forming cells of the neoplasm.

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PROBLEMS IN PARTIAL DENTURE SERVICE

By CARL O. FLAGSTAD,* D.D.S., Minneapolis, Minn., and FRED C. ELLIOTT,† D.D.S., Houston, Texas

DR. ELLIOTT: *What are the major problems associated with partial denture service?*

DR. FLAGSTAD: Partial dentures are a liability to the health of the mouth because of the difficulty of solving the following problems:

(a) Securing and maintaining equalized stress between the natural and the artificial teeth.

(b) The danger of injury to abutment teeth from the attachments.

(c) Increased uncleanliness and liability to inflammation because of the presence of the partial denture.

The operator should recognize these problems when advising and designing partial dentures.

DR. ELLIOTT: *What examination and records should be made prior to taking an impression for a partial denture?*

DR. FLAGSTAD: (a) Complete x-ray pictures are essential to diagnosis.

(b) A record should be made of the diagnostic examination and the mouth history.

(c) Study models are desirable, especially if construction is complicated.

(d) The financial status of the patient should be determined so that a restoration within his financial means may be planned.

(e) The fees agreed upon should be

Topic discussion presented before the Section on Partial Denture Prosthesis at the Eighty-Third Annual Meeting of the American Dental Association, Houston, Texas, October 29, 1941.

*Professor of denture prosthesis, University of Minnesota, School of Dentistry, Discussor.

†Professor of dental prosthesis, Texas Dental College, Leader.

definitely recorded, to avoid future misunderstandings.

DR. ELLIOTT: *What are some of the practical suggestions for designing partial dentures?*

DR. FLAGSTAD: (a) A decrease in tissue area to be covered necessitates an increase in the number of rest lugs and supports on the remaining teeth.

(b) Only necessary retention should be planned.

(c) The teeth most favorable for attachments as regards health, location, structure and appearance should be selected.

(d) The appliance should be so designed that it can be worn with safety and the greatest comfort to the patient.

(e) The design should minimize uncleanliness and inflammation.

DR. ELLIOTT: *Is it possible to secure balanced occlusion and maintain it in partial dentures?*

DR. FLAGSTAD: It may be possible to secure balanced occlusion at the time of insertion of the partial denture, but to maintain it for any length of time is almost impossible. Even in favorable types of partial dentures, in which sufficient lugs and stops can be placed, the occlusion will generally change, because the metals will bend and the abutment teeth will intrude and shift.

DR. ELLIOTT: *How can possible injury from undue stress to abutment teeth be minimized?*

DR. FLAGSTAD: Properly constructed attachments, lugs and stress-breakers, and frequent observation after the denture has been inserted, will reduce the possibility of injury from stress.

DR. ELLIOTT: *How does partial denture service compare in efficiency with other branches of restorative dentistry?*

DR. FLAGSTAD: If liability and risks involved are considered, it compares reasonably well. The necessity for partial dentures frequently arises at the beginning of the period of greatest destruction in the mouth, from progressive disease. It is questionable whether the subsequent loss of teeth is chargeable to the wearing of partial dentures or to certain systemic destructive processes which it seems impossible to control.

DR. ELLIOTT: *What are some of the factors in determining the length of service a partial denture will render?*

DR. FLAGSTAD: Length of service may be determined by:

(a) The mouth history. Have there been caries, disintegration and disease, or has the mouth been healthy?

(b) The systemic health.

(c) The type of construction required.

(d) The mouth hygiene. The habits of oral care are well formed at the time when partial dentures become necessary, and the chances are that they will not change greatly in the future.

(e) The present condition of the mouth and teeth.

DR. ELLIOTT: *What impression technics apply to partial dentures?*

DR. FLAGSTAD: Compound; plaster and pastes; elastic materials, and a combination of materials are used. An impression technic is efficient in proportion to the operator's judgment, skill and vision.

DR. ELLIOTT: *What of the retention of partial dentures and the requisites for an attachment?*

DR. FLAGSTAD: There are two general means of retention for partial dentures: clasps of various types and slotted attachments of different kinds.

The requisites of attachments are: adequate retention, yet not locking the denture; minimizing of danger of disintegration and disease of abutment teeth; sufficient spring to permit resiliency of tissue, and adequate strength.

DR. ELLIOTT: *Why does the partial denture require more servicing than any other type of dental restoration?*

DR. FLAGSTAD: (a) There is

greater danger of damage to the denture and the remaining natural teeth.

(b) The construction is more delicate and complicated; which increases the liability to distortion and breakage.

(c) Tissue changes frequently alter the relation of dentures and the attachments to the natural teeth so that adjustments are necessary.

(d) Disease may develop in the remaining teeth and may require removal of the tooth or teeth, with the necessity of making additions to the denture.

DR. ELLIOTT: *What major difficulties that develop in partial dentures over a period of time require service?*

DR. FLAGSTAD: The following are common difficulties: (a) Adding teeth to the partial denture. (b) Settling of the partial denture. (c) Impingement of bars and saddles on tissue. (d) Breakage of attachments and their replacement.

DR. ELLIOTT: *In partial denture cases, how can the bite be opened and maintained? What are the limitations?*

DR. FLAGSTAD: It is impossible to open a bite with a partial denture and maintain it very long unless the opposing natural teeth are built up to the desired level with crowns and inlay or overlay lugs. Usually, it must include a number of such teeth since there must be sufficient bearing on the natural teeth to control the tendency to intrude.

The limitations on opening a bite on a partial denture will depend on the safety limit to which we can build up the natural teeth or to which we can reposition the lower jaw in relation to the upper.

DR. ELLIOTT: *What is the consensus of opinion regarding the choice of base metals for partial dentures and also the substitutes for vulcanite?*

DR. FLAGSTAD: The general opinion is that the base metals, such as vitallium, ticonium and wipla, are superior in many respects to the gold alloys because of the following qualities: (a) Permanency of color, due to freedom from oxidation. (b) Strength. (c) Weight. (d) Cheapness.

The disadvantage of the base metals is the inability to process it in the average dental office. This has given much concern to the profession because it has made possible the control of materials and technics by commercial firms.

The acrylics are a satisfactory substitute for vulcanite.

DR. ELLIOTT: *What are the chief causes for rapid resorption of tissue under partial dentures and how is it possible to control it?*

DR. FLAGSTAD: The causes are:

(a) Overretention, locked retention

(b) Stress of occlusion, chiefly on partial dentures.

(c) Type of tissue and the tissue area covered.

It can be partially controlled by:

(a) Equalized occlusal stress between natural and artificial teeth on insertion of the denture.

(b) Proper placing of lugs and stops.

(c) Frequent observation of the case so that necessary adjustments to changing conditions can be made.

DR. ELLIOTT: *How should a prospective partial denture patient be advised concerning this service?*

DR. FLAGSTAD: A patient should be honestly apprised of the liabilities associated with the partial denture and this information should be based on a careful diagnosis of all the factors. The decision as to the type of partial denture to be inserted should not rest upon the patient's ability to pay, but rather on the merits of the service that the denture will render.

EXCESSIVE EXPANSION OF DENTAL AMALGAM*

By Irl C. Schoonover,† Wilmer Souder,‡ and John R. Beall,#
Washington, D. C.

INTRODUCTION

THE better grades of amalgam alloys will expand slightly during the first ten to twenty hours after amalgamation. It is quite generally agreed that this expansion should be in the neighborhood of 8 microns per centimeter and that subsequent expansion (or contraction) is cause for concern on the part of the dentist.

These subsequent changes in dimension are almost certain to impair the usefulness of the restoration. Expansion may cause the extrusion of the restoration beyond the tooth margins or may create painful disturbances in the pulpal chamber if undercuts or other marginal lockings are used. Contraction causes the separation of the restoration from the retaining walls of the tooth, resulting in leakage and thus inviting recurrent decay.

Some amalgams that showed 8 microns expansion in laboratory tests, and no subsequent dimensional change, have, when used clinically, shown subsequent changes, or have caused pain. In many instances, it was necessary to remove the restorations. Dentists have reported that the same brand of alloy has shown the foregoing defects in some restorations and not in others.

This type of expansion has no relation to the initial 8 micron beneficial expansion of the first twenty hours. A period of from two to seven days of apparent dimensional stability usually exists between the initial expansion and the beginning of the delayed action. Excessive expansion as great as 300 and 400 microns per centimeter has been measured.

This continued growth of amalgam has been designated as "delayed expansion" to differentiate it from other known types of excessive expansion caused by such factors as excess mercury, under trituration and composition as observed by Souder and Peters,[1] Ward and Scott[2] and others.

A number of investigators have observed this delayed reaction. Various explanations have been proposed as to its cause, none of which has satisfactorily explained all cases, nor has any safeguard for prevention previously been offered. Worner[3] reported that the temperature on trituration was the important factor. He observed that amalgams triturated at 35° C. showed little or no tendency to expand, while specimens prepared from the same alloy, but triturated at 13° C. and 0° C., expanded excessively over a period of many months. Skinner[4] reported continued growth of some alloys and attributed it to the use of an extremely fine cut alloy and the practice of using a "wet" (excess mercury) mix on the floor of the cavity.

Crowell,[5] Liebig,[6] Ray,[7] and Strader[8] observed this type of expansion and believed it to be caused in some manner by the practice of "palming" amalgam. Sweeney[9] observed delayed expansion when amalgam containing small amounts of zinc was "palmed." Black[10] at one time claimed that zinc was not permissible in amalgam alloys because of the tendency of such alloys to expand

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Gray[11] observed that an amalgam containing zinc expanded for a period of more than eight months. However, Gray stated "that the abnormal expansion is not attributable to the zinc contained in the alloy."

No one of the reported factors in expansion—the temperature of trituration, the presence of zinc or the practice of palming—will account for all cases of merçury, undertrituration, etc.; (3) only those alloys which contain zinc respond, and then only when they are contaminated with salt solutions or moisture during trituration or placing of the alloy; (4) evidence as to the cause of the expansion is now at hand, and (5) a feasible technic is available which will preclude the development of this expansion.

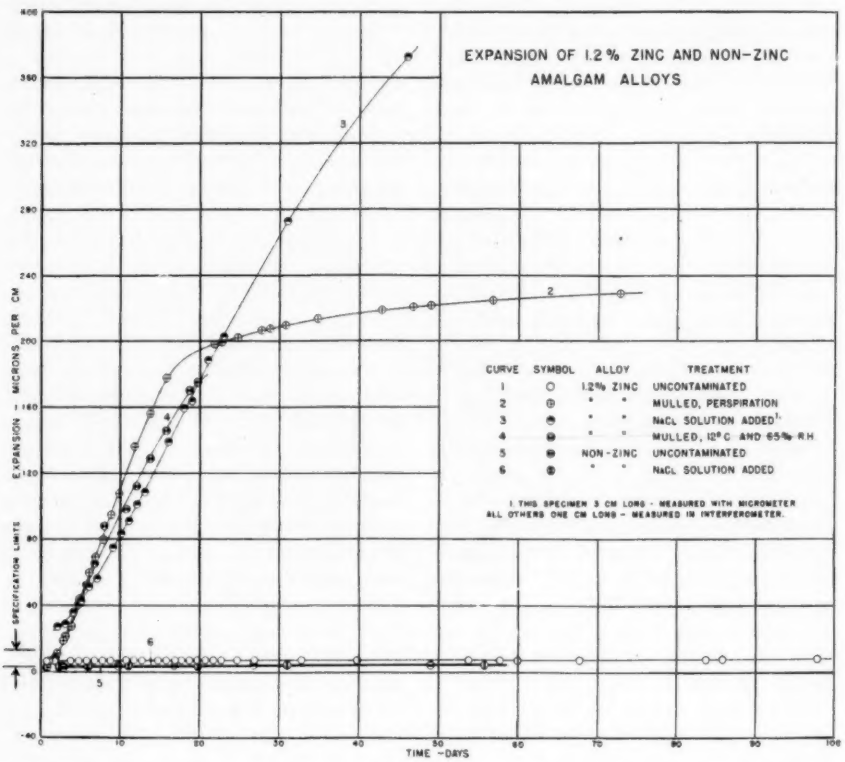
EXPANSION OF 1.2% ZINC AND NON-ZINC AMALGAM ALLOYS
EXPANSION MICRONS PER CM
SPECIFICATION LIMITS
TIME - DAYS
CURVE SYMBOL ALLOY TREATMENT
1 ○ 1.2% ZINC UNCONTAMINATED
2 ⊕ " " MULLED, PERSPIRATION
3 ◓ " " NaCl SOLUTION ADDED[1]
4 ⊖ " " MULLED, 12° C AND 65% R.H.
5 ⊜ NON-ZINC UNCONTAMINATED
6 ◉ " " NaCl SOLUTION ADDED
1. THIS SPECIMEN 3 CM LONG - MEASURED WITH MICROMETER
ALL OTHERS ONE CM LONG - MEASURED IN INTERFEROMETER.

Figure 1.

excessive growth, as will be demonstrated in the experiments described in this report.

In these experiments, it was demonstrated that (1) some amalgam can be made to expand excessively; (2) this expansion differs from expansion caused by such well-known factors as excess of

EXPERIMENTAL DATA

Effect of Palming.—Experiments were made to determine whether "hand mulling" or "palming" would cause amalgam to expand excessively. One lot of alloy which contained silver 68.4 per cent, tin 25.9 per cent, copper 4.6 per cent and zinc 1.2 per cent was thoroughly washed

with distilled water and air dried. Two specimens for expansion measurements were made from this material.

The specimens were prepared by mixing in a mechanical amalgamator and packing in steel dies. For one specimen, care was taken throughout this procedure to avoid touching the amalgam. This specimen was not mulled in the hand. The second specimen was prepared in the same manner except that the alloy, after removal from the amalgamator, was mulled in the palm of the hand, which was thoroughly wet with perspiration at the start of mulling. Both specimens were placed in a constant temperature cabinet maintained at 37 $\pm 0.5^{\circ}$ C. Measurements with interferometers to determine the amount of expansion were made for a period of seven months. The results are illustrated in curves 1 and 2, Figure 1. Both alloys behaved normally for the first two or three days, after which the specimen prepared from the "mulled" amalgam (curve 2) began to expand, continuing to do so until the experiment was discontinued, at which time the change in dimension was 229 microns per centimeter. The specimen which was not mulled changed only 3.5 microns per centimeter in 199 days. These experiments were repeated with other specimens prepared in the same manner and the same results were obtained.

Other experiments were made in which a drop of salt water was placed in the capsule of the mechanical amalgamator with the clean alloy and mercury during trituration. A cylindrical specimen (30 mm. long and 5 mm. in diameter) was prepared from this amalgam. Another specimen was prepared in the same manner except that it was kept free of contamination. Neither of the amalgams was mulled. The dimensional changes of both were measured with a micrometer. Both specimens behaved normally for the first few days, after which the amalgam to which salt water was added began to expand, continuing to do so for six weeks, after which measurements were discontinued (curve 3, Fig. 1). The total expansion at this time was 373 microns per centimeter. The uncontaminated specimen did not exhibit delayed expansion.

Fig. 2.—Blisters on disk of amalgam.

Other experiments were made as follows: One specimen was prepared from amalgam palmed in the hand well mois-

tened with perspiration. Another was prepared in the same manner, except that the hands were covered with rubber gloves during the mulling technic. A third specimen was prepared from amalgam mulled in the hands after they had been well washed and dried. Delayed expansion was observed only on the specimen mulled in the moist palms. Other experiments were made in which water alone was added during trituration. Excessive expansion developed.

These experiments demonstrated that moisture is the important factor in producing delayed excessive growth of amalgam. The work of the other investigators mentioned previously substantiates this conclusion, since the presence of moisture is demonstrable in all cases of excessive growth reported.

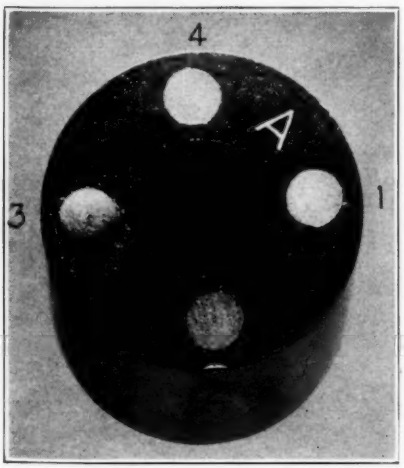

Fig. 3.—Expansion of amalgam plugs (containing zinc) placed in steel die. 1, amalgam mulled in hands (15 per cent relative humidity). 2, amalgam not touched by hand. 3, amalgam mulled in hand moistened with salt solution. 4, amalgam mulled in clean, dry hand.

Effect of Temperature.—Further confirmation of the rôle that water plays in the delayed expansion of amalgam was obtained in the following experiments extending Worner's[3] work on the effect of temperature during trituration, which he considered the important factor in delayed growth. The procedure followed was essentially that described by Worner. Specimens were prepared from amalgam triturated at 21° and 12 ± 1° C. in a room in which the relative humidity was constant at 65 per cent. The 21° temperature is above the dew-point, while the 12° temperature is below the dew-point at this humidity. The amalgam for each specimen was mulled in the finger of a rubber glove and the specimens were prepared without being touched with the hand. The expansion was measured with interferometers. After twenty days, the specimen triturated at 12 C. had expanded 175 microns per centimeter (curve 4, Fig. 1). The specimen prepared at 21° C. showed no

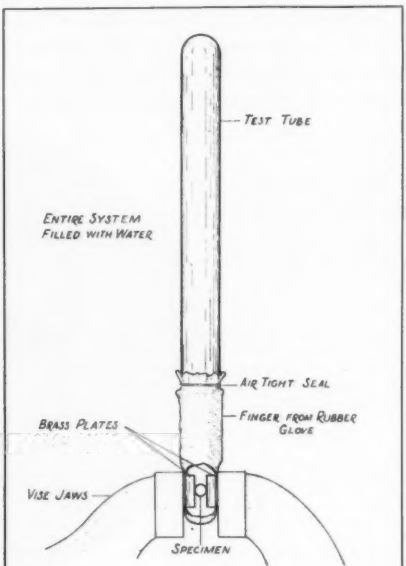
TEST TUBE
ENTIRE SYSTEM FILLED WITH WATER
AIR TIGHT SEAL
FINGER FROM RUBBER GLOVE
BRASS PLATES
VISE JAWS
SPECIMEN
DEMONSTRATION OF PRESENCE OF HYDROGEN GAS IN AMALGAM SPECIMEN WHICH HAD SHOWN EXCESSIVE, DELAYED EXPANSION

Figure 4.

tendency to delayed growth. Both of these observations are in accord with Worner's findings. However, expansion was not observed (less than 3 microns per centimeter) in another specimen prepared at 12° C. under such conditions that no moisture condensed on the alloy, mercury, container or amalgam during the procedures of mixing, mulling and condensing.

The temperature at which trituration is done is therefore very important, if it is such that moisture will condense on the amalgam.

Effect of Zinc.—In the experiments described above, the alloys contained 1.2 per cent of zinc. While these experiments were in progress Sweeney[9] reported that he was unable to obtain delayed growth of non-zinc amalgams. Experiments, previously reported,[12] were made, in which some specimens were prepared from a non-zinc amalgam to which a salt solution had been added during trituration, and others were prepared from uncontaminated non-zinc alloy. Delayed expansion was not observed on any of these amalgams (curves 5 and 6, Fig. 1). Failure of these non-zinc alloys to exhibit delayed growth is made clear by the following investigation to determine the mechanism by which moisture added to amalgam alloy produces excessive growth.

The Effect of Moisture.—In a previous publication,[13] entitled "Corrosion of Dental Alloys," the formation of blisters on the surface of some specimens was reported. (Fig. 2.) These blisters were thought to be caused by the formation of gas within the alloy as the result of galvanic corrosion. The specimens had been prepared during the summer and were known to have been mulled, and were therefore, probably contaminated with perspiration. The possibility that the observed delayed expansion was caused by galvanic action was, therefore, investigated. This explanation proved to be correct, as is demonstrated in the following tests.

Experiments were prepared to determine whether chemical reactions between the constituents of an amalgam and salt solutions would produce gas. Dilute sodium chloride solutions (1 per cent) were added to mixtures of mercury-silver, mercury-tin, mercury-copper and mercury-zinc in such a manner that any gas formed could be collected and examined. The contact of only one of these combinations, mercury and zinc, with the sodium chloride solution, produced a gas, which was identified as hydrogen.

Other experiments were made in which cylindrical specimens of amalgam (30 mm. long and 5 mm. in diameter) were prepared, free of any contamination, from zinc and non-zinc alloys. They were crushed after they had hardened and were placed in glass test tubes. A small quantity of salt water was added to each and the tubes were sealed immediately. After one week, the tubes were attached to a gas analysis apparatus and opened, and any gas formed was analyzed. Hydrogen was present in the tube containing the zinc amalgam, but not in the tube in which the non-zinc amalgam had been placed.

Further tests were made to determine the pressure exerted by the gas formed within the amalgam. For these experiments, cylindrical specimens (30 mm. long and 5 mm. in diameter) were prepared from an amalgam containing zinc (1.2 per cent). A few drops of salt water were added to some of the specimens and distilled water to others during trituration. These specimens were weighed in air and in water to determine their density. Further weighing in water was done over a period of twenty days to follow the volume changes. The specimens were dried and stored between weighings in a container maintained at a constant temperature of $37 \pm 0.5°$ C. At the end of the twenty days, the amalgams were placed in glass tubes and covered with mercury and the tubes

sealed. These tubes were heated until the amalgams dissolved in the excess mercury, thus liberating any gas contained in them. The amount and kind of gas were determined. Two of the specimens to which salt water had been added yielded 6 and 7 milliliters of hydrogen respectively when measured at atmospheric pressure. The specimen to which distilled water had been added yielded 4 milliliters of the same gas. From the total volumetric expansion and the amount of gas contained in this volume, calculations were made of the minimum pressure that might have been exerted by the gas within the amalgam. These pressures were 2,000, 2,200, and 1,600 pounds per square inch, respectively, for the above-mentioned quantities of gas found and are ample to cause the amalgam to flow. They were calculated on the assumption that no additional hydrogen was formed in the process of solution of the amalgam. Some gas was observed to have escaped from the specimens before they were dissolved, through the rupture of small blisters formed near the surface.

Further evidence of the formation of gas within contaminated zinc amalgams was obtained when cylindrical specimens which had been expanding for one month were placed in gas-free distilled water and were then heated. Gas escaped from the specimens, forming droplets of mercury on the surface. This may explain the results obtained by Gray[14] on the "bleeding" of mercury by zinc alloys, which he attributed to a transformation occurring at about 70° C. It is at this temperature that the most copious flow of hydrogen gas was obtained from the zinc alloys. Gas was not obtained from non-zinc alloys treated in a similar manner, nor were the mercury droplets apparent.

Other experiments were made with cylindrical specimens of alloys with and without zinc (30 mm. long and 5 mm. in diameter), prepared so as to be free of any contamination. These specimens were carefully measured and placed in a saturated salt solution. The following day a few gas bubbles appeared on the surface of the alloy containing zinc, but not on the alloy without zinc. Measurements of expansion were made at intervals of time over a period of four months. Neither specimen exhibited delayed expansion. This is as anticipated. Gas should not form within an uncontaminated amalgam when the set or hardened specimen is immersed in water or salt solution.

Another characteristic of delayed expansion produced in contaminated amalgam and observed in these experiments is that the corrosion is not uniformly distributed throughout the alloy. Some specimens were observed to bend and others were covered with many small blisters formed near the surface. Such blisters have since been observed on actual restorations.

The characteristic delay of this expansion is adequately explained with the data obtained thus far. The period of inactivity prior to the beginning of excessive growth can well be accounted for by the fact that, during this period, the gas pressure is insufficient to cause the amalgam to flow. This may also account for the cases of postoperative pain often reported from two to seven days after a filling is completed.

Two simple experiments which can be made in the dental laboratory, illustrated in Figures 3 and 4, will show both the magnitude of expansion and the volume of gas in contaminated zinc amalgams.

Figure 3 shows a steel block in which holes were drilled (4.5 mm. in diameter and 11.5 mm. deep) and filled with an amalgam containing zinc. Amalgam 1 was palmed in March (relative humidity, 15 per cent) without any attempt to clean the hand. Amalgam 2 was not touched by the hand. Amalgam 3 was palmed in the hand wet with salt solution. Amalgam 4 was palmed in the

hand previously washed with alcohol and dried. Slight expansion was observed on two of the amalgams palmed. Excessive expansion was observed on amalgam 3, which was palmed in the wet hand. No expansion was observed on the amalgam not palmed.

Figure 4 illustrates the experiment for showing the presence of gas in the amalgam. In this experiment, a contaminated zinc amalgam 3 or 4 weeks old was placed in the finger of a rubber glove under water, which was then securely fastened to a test tube also under water. The amalgam was crushed. The gas bubbles liberated rose in the test tube. In some cases, the volume of gas liberated was greater than the volume of the amalgam, thus proving that the gas was under pressure within the amalgam.

RESULTS

These experiments have demonstrated that:

1. Delayed expansion of amalgam containing zinc is caused by a chemical reaction between the amalgam and water accompanied by the evolution of hydrogen.

2. The moisture may be introduced by (a) palming in a moist hand, (b) trituration or placing amalgams which are sufficiently cold to cause water to condense on them, (c) accidental contact with saliva or (d) placing amalgam in a wet cavity.

3. The practice of mulling amalgam is bad unless great care is taken to cleanse and dry the hands.

4. Non-zinc alloys do not exhibit delayed expansion of this type.

5. Zinc alloys do not exhibit any tendency to expand excessively if they are not contaminated.

CONCLUSION

The question arises as to the suitability for dental use of amalgams containing zinc. The answer would seem to be that excessive continued expansion of these alloys does not occur unless they are contaminated. If, in practice, cleanliness is maintained at the time of amalgamation and during the placing of the restoration, no trouble should be encountered. Furthermore, alloys containing zinc are giving and have given excellent results and have some characteristics which make them better suited to dental practice than are non-zinc alloys. Certainly, until a non-zinc alloy is produced which is as free of manipulative difficulties as the present zinc alloys, the dental profession should not discard alloy containing zinc. Changing from a zinc to a non-zinc alloy to avoid the necessity of reasonable cleanliness of the palm and amalgamating equipment may develop a false sense of security, since undesired effects, other than delayed expansion, may accompany the use of contaminated non-zinc alloys.

Excellent restorations can be made with amalgams containing zinc, provided the technic used includes the following precautions: 1. All equipment should be clean and dry. 2. Mulling, if employed, should be done in a finger stall or with rubber gloves on the hands. 3. The temperature throughout the operations of amalgamating, of mulling and of placing the restoration should be such that no moisture will condense on the amalgam. 4. The amalgam should not come in contact with saliva. 5. The cavity should be reasonably dry. 6. The fingers should be wiped clean and dry if it is necessary to touch the amalgam.

Obviously, the foregoing precautions are compulsory also for non-zinc alloys if one maintains acceptable manipulative procedure.

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CAVITY PREPARATION

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THE classification of cavities into Class I, pits and fissures; Class II, proximal surfaces of bicuspids and molars; Class III, anterior teeth not involving the angle; Class IV, anterior teeth involving the angle, and Class V, gingival third cavities, along with the outlining of different steps of cavity preparation, such as outline, resistance, retention, convenience, removal of remaining decay, bevel of margins and toilet of cavity, was certainly a long step forward to systematic cavity preparation. The accomplishment of any project is more efficient and prompt when a preconceived plan is followed.

This plan of procedure does not, however, mean that all cases which come in the same general category are to be handled exactly as if this were mass production. It does, however, give us a standard from which we may deviate because of any one factor, or a combination of several factors in the program that we are executing. Also, the fact that different cases present different problems challenges the ingenuity of the operator.

Some of the factors which have to be considered are the nature of the material for which the cavity is being prepared, the age and the physical condition of the patient, the extent of the destruction which we are called upon to repair, the demands of the technic which we wish to employ, the position of the individual tooth within the arch, the degree of rotation and of eruption and the character of the structure of the teeth; all these factors and the newer concept which recognizes dentistry as a health service and takes into account the fact that restorative procedures are not purely mechanical, but must be correlated with the biologic sciences. In other words, our concept now is biomechanical.

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Before discussing the effect of these factors on preparation, let us consider some of the general principles involved. One of the first that come to mind is diagnosis. In the light of our present knowledge, gathered from the results of research and clinical experience, we must first use all the means of diagnosis at our disposal, in order to render the desired quality of service. What are the means of diagnosis involved? First, we wish to be sure of the state of health of the patient that we are working for, realizing that the preparation of the individual tooth is not a single isolated project. This assurance of general physical welfare can be ascertained through history and, if necessary, be substantiated by the findings of the physician. More particularly, as we come to a specific operation, we wish to be sure of the state of health of the individual tooth and its supporting structures, the extent of caries involvment, the proximity of the pulp and the evidence of pulp reaction. This will indicate the use of roentgenography, the periapical film supplemented by the bitewing. The relationship of the tooth tissues of the coronal portion, in which we are vitally interested, is more clearly defined in the bitewing than in the periapical because of the angle at which they are taken. This is more evident in the upper than in the lower. Vitality can be determined by the use of the electric pulp tester, or a temperature change by ice or hot instruments or a hot stick of temporary stopping. The use of transillumination to determine the extent of a carious lesion or to verify suspected lesions is also very helpful.

The next general principle to be observed is the establishment of a definite program to be followed. This makes for more efficient work for several reasons: 1. The patient knows what can be done and what to expect from what is done. 2. The operator, having determined what the procedure is to be, can conserve time by carrying out the plan previously agreed upon. 3. With a thorough understanding beforehand, the most fertile field of dissatisfaction has been removed. Ninety-five per cent of the difficulties arising after the completion of work are due to misunderstandings. We may feel that it is difficult to lay out a whole program if the patient wants only certain things done; but, if the advantages of doing it that way are explained to him, and the fact that what is to be done at the time is a part of a plan which will be completed as circumstances permit, he will generally agree.

Another general principle is the care and use of equipment necessary for the desired result. The equipment should include a supply of sharp, good quality burs and stones and a set of hand instruments. It is a sound practice to keep a supply of burs because, with old burs, it takes longer to do the work and more pain is caused in doing it. Cheap burs are no economy because they lack quality and are not well designed. A supply of stones is a great help. In many cases, the preparation can be carried out with a stone less painfully than with a steel bur. Stones should be of various shapes, and should be kept true and clean. A good stone is one which will wear as it is used. If it is so hard that it does not wear, it will not cut, and it has to be kept true in order to avoid an excess of vibration. Also, stones will fill, particularly if they are used in remains of fillings, and the filled-in surface must then be removed with a stone truer.

The use of hand instruments is a great aid in cavity preparation. They can be used to obtain detail of preparation which is not possible with motor-driven instruments. In large cavities in which there is overhanging enamel to be cut away and the outline must be extended to immune areas, hand instruments do the work quickly. If a part of the outline form must be made in sensitive areas,

hand instruments are used in combination with burs, which are used only to undermine, and the chisels, which are used to chip away and to create the desired outline, this reducing the amount of cutting to be done with the burs and making it less painful. In deep-seated cavities, excavating is more easily and surely controlled with hand instruments than with the bur. Also, it will be found that the majority of patients prefer hand instruments.

The materials commonly used for restorative work are gold foil, amalgam, silicate, the cast gold inlay and baked porcelain. In Class I cavities, that is pits and fissures, the restorative materials are usually gold foil or amalgam, or a cast gold inlay if the cavity is large.

In preparation, no matter what the material, the first step is opening the cavity and establishing the outline. If small, the cavity can be opened with a round bur No. ½ or 1, and the resistance form can be created with a cross-cut fissure bur. If the restoration is to be of gold foil, convenience points at which to start the filling are necessary. The retention form will not need to be so definite as if amalgam were used because the technic employed in inserting the foil, namely malleting, causes it to be wedged between the walls. Further, the only force tending to dislodge this type of filling is a direct pull with sticky foods. A knowledge of the microscopic anatomy of the tooth and clinical experience warn us that, where foil is inserted, the cavosurface angle should be beveled, to prevent fracture of the enamel rods and for a permanent seal. The nature of the gold will provide for this, while, in the case of amalgam, because of the low-edge strength of the material, we are as well or better off with no bevel of the cavosurface angle.

With the cast gold inlay, which demands for its construction a technic allowing the removal of either a wax pattern or an impression, depending upon whether a direct or an indirect technic is used, the cavity preparation must afford walls which are slightly flared to allow for removal of the pattern or impression. This necessitates a variation in retentive form. We cannot depend on positive undercut retention, but must use frictional retention of the lateral walls.

If the cavity is large enough to take in enough of the occlusal surface to involve the slope of the cusp to the point of leaving enamel rods unsupported, the cusp should be reduced so that it can be restored with the material of the filling. If gold is to be used, the bulk does not need to be so great, but if amalgam is used, there should be sufficient bulk. When amalgam is used, the cavosurface is not beveled because of the low-edge strength of the material.

If the cavity is deep, the flat floor, for resistance, should not be created by reducing the cavity to the deepest part, since this may endanger the pulp, especially in young teeth or teeth in which the expected amount of secondary dentin has not been deposited. In these cases, the cement base should be used to make the flat seat by filling in the deepest part. In the use of the cement base, when the cavity presents a cup-shape before the cement is placed, the floor must extend beyond the margins of the cup when the preparation is finished so that a part of the floor is in sound dentin. The filling, as it is inserted, will then be anchored in sound tooth structure and the forces applied will not be concentrated on the cement base.

Class II cavities, those occurring on the proximal surfaces of bicuspids and molars, should include the occlusal surface as well, to secure adequate retentive form. However, occasionally when the tooth is caries-free on the occlusal surface and enough sound structure remains in the buccal and lingual walls to allow retention, the channeled proximal box without the step may serve very well.

With the usual preparation, the one

involving the occlusal surface, the proximal box area is prepared with a convergence of the buccal and lingual walls gingivoclusally. The gingival floor should have an inward inclination and the buccal and lingual walls should be extended to the minimum for prevention. The bevel is placed entirely around the cavosurface. The gingival wall is beveled with gingival marginal trimmers, the occlusal, as in the Class I, with chisel or fissure bur or mounted stone and the buccal and lingual walls with sandpaper disks. The retentive form of the proximal wall is cut at the expense of the buccal and lingual walls, starting at either gingival point angle with a small round or inverted cone or tapered crosscut fissure bur, cutting a groove which runs out to nothing just below the axiopulpal line angle. The sharpness of the groove may be accentuated with line anglers. If necessary for convenience in starting the filling, small convenience points can be placed at the gingival points with small inverted cone burs.

The occlusal retention is secured with the dove-tail and undercut form at the margin opposite the proximal box. Here again, if necessary, convenience can be secured by the use of small inverted cone burs in the retention form. The bevel of the axiopulpal line angle is very important, removing the shear strain and at the same time adding materially to the strength of the restoration. With the preparation of the gold foil as a basis, the variation necessary for the acceptance of amalgam is some extension and deepening of the whole cavity. The bevel is eliminated except at the gingival and axiopulpal line angles. Ward has suggested an excellent variation in the retentive form, advising the placement of a definite groove in the buccal and lingual walls, continuing across the gingival floor. This offers advantages in that the material can be securely locked in. If the buccal and lingual walls have been deeply undermined by caries and are subsequently supported with cement so that a good part of the length of the groove is in cement, the gingival groove portion can always be in sound dentin.

In preparing Class II cavities, the most difficult tooth that we are called upon to prepare is the lower first bicuspid. Because of its anatomic form with its large, heavy buccal cusp and low lingual cusp, it presents several problems. First, the bur seems to follow the path of least resistance and, if we are not careful, as we cut across the occlusal surface, we find that we are turned from the heavy buccal cusp and to the small lingual one, and we eliminate some or all of the retention that we can secure by dovetailing around the bulk of the lingual cusp. Second, the difference in the height of the two cusps gives the occlusal plane of the bicuspid from buccal to lingual aspect a decided inclination. Also, the pulp horn is high in the buccal cusp, and if the preparation is started at the lingual cusp and crosses to the buccal cusp without cutting the floor of the cavity in harmony with the plane of the occlusal surface, we may cut so deeply on the buccal cusp as to endanger the health of the pulp. Third, the variation in occlusal anatomic form may be so great as to make it impossible to secure sufficient retention with the conventional Class II preparation, and we may have to resort to the inclusion of additional tooth surface, or the use of pins, to secure retention.

The materials of choice in Class III cavities, those cavities occurring on the proximal surfaces of the anterior incisors, not involving the angle, are gold foil, silicate, baked porcelain and the cast gold inlay. The gold foil outline is sufficient to allow for extension and convenience for insertion. If the outline comes to the contact area, it is safer to extend the outline to a point beyond, so that the margin may be at a point of immunity to caries and strain. The cavosurface angle, as in all gold foil prepara-

tions, should have a continuous bevel. The retention form is created by the use of an inverted cone in the two gingival angles and the incisal angle, then by accentuation of this form by the use of line anglers. If necessary, convenience starting points may be used within the retention areas.

Silicate is, undoubtedly, more widely used than foil, in spite of its temporary quality. The outline form for the silicate need not be so extensive as for foil. First, because of the lack of permanence of silicate, it must be replaced more frequently. Second, the silicate does not present the difficulty of insertion, because of its plasticity. There is some difference in the retention form for the silicate and for the foil: the sharp, well-defined retention which adds to the convenience in manipulation of foil is not necessary with silicate, and, in the minds of some operators, is a disadvantage because the packing of the plastic mass is more easily accomplished if the form is rounded. They believe that there is less likelihood of failing to get into the sharp angles and losing retention. The bevel of the cavosurface angle is not desirable, because of the weakness of the material.

The baked porcelain inlay affords a very good restoration, but is not generally used, probably because of the technic and economic considerations involved. However, when it is used, the preparation is made either with the general outline of Class III cavity, or it may be made for insertion from the lingual aspect, with a channeled box or a step with a lingual lock. If sufficient separation can be secured in the case presented, it can be taken care of with the standard outline, and the cavity is prepared with a slight flare and no cavosurface bevel, the inlay being set to place from the proximal aspect. If the channel box type of preparation is to be used, the preparation of the labial margin is important for an esthetic result. It should be prepared as nearly at right angles to the labial surface as it can be so that, in cementation, the joint will be as narrow as possible. If it is prepared with a long flare, the result is a wider joint, because of the opacity of the cement. The channels of the box should be rounded to allow for the adaptation of the matrix and the baking of a well-fitting inlay. The same treatment of the labial margin applies in cases where the step is used. The preparation of the step to the lingual lock, so that it is well rounded, is important for two reasons: First, the preparation is made to receive a friable material, and every precaution should be taken to guard against subsequent fractures, which means the loss of the filling. The location of the most likely point of fracture is at the step. By rounding this step, we remove the shear strain. Second, by seeing that the step portion is rounded, we supply the maximum bulk of material.

The cast gold inlay is also used, particularly on the distal surfaces of the cuspids. It is used in a preparation of the channeled box or step. The chief problem is the withdrawal of the pattern or impression. The bevel generally used with the inlay preparation must be eliminated on the labial margin if the path of insertion is directly lingual. Sometimes, if the cavity is small, tooth structure can be conserved by using the slice preparation in combination with the proximal box, particularly if there is, as is frequently the case, a decided distal bulge.

The line of insertion of the finished restoration should be kept in mind as the preparation proceeds. The most convenient line is usually from the lingual aspect at an angle of about 45 degrees to the labial. If this is kept in mind, the box will take this angle and conserve the tooth. If not, sometimes the box must be made larger to permit insertion. The use of the cast gold inlay is not, however,

limited to the cuspid. There are cases in which it is used on the other anterior teeth much the same as the porcelain inlay except that we may use bevels if the insertion is from the proximal aspect. If the insertion is from the lingual aspect, we may bevel all except the labial portion, and there need not be so much rounding of the step. In fact, so much rounding as is used with the porcelain preparation might not be desired if it brings the metallic filling into closer proximity with the pulp.

The Class IV cavities which occur on the proximal surfaces of the anterior teeth and involve the angle are usually prepared to receive gold foil, cast gold inlays or baked porcelain. The nature of silicate, unless it is used in conjunction with gold, contraindicates its use. In my opinion, the use of gold foil is limited to those cases in which the tooth is thick enough labiolingually to permit a preparation which can be made so that the remaining incisal edge is not involved. If the remaining incisal edge must be utilized for retention, the cast gold inlay is indicated. However, where the undercut Class IV foil preparation, let us call it, in contradistinction to Class IV with incisal extension, can be used, it serves very well, allowing for a lasting restoration with a minimum sacrifice of tooth and a minimum display of gold.

The cast gold restoration employs two types of retention form, either the pin or the lingual lock. In the short stubby anterior tooth, where there is a good bulk of dentin between the enamel plates and where, with the minimum cutting of the incisal edge, the pinhole may be prepared in the dentin, the pin type is indicated. In the long thin tooth, where practically the whole of the incisal third is formed by the buccal and lingual enamel plates, with little or no dentin interposed, the lingual lock type is indicated. This form offers better retention in this type of tooth. It is better esthetically because it does not display so much gold as if the pin were used, and it also offers a safer preparation as far as pulp protection is concerned, because, many times, as the cross-sectional study of this type of tooth reveals, the pulp is also relatively close to the incisal edge and would be endangered by much cutting.

In the preparation of the Class IV cavity for pin retention, several points should be kept in mind: First, the proximal box should have as much of the labial and lingual surfaces retained as possible to procure maximum resistance to any torque applied to the incisal corner being restored. Second, the incisal edge should be reduced on an angle toward the lingual surface, allowing greater bulk, but keeping the display of gold to a minimum on the labial surface. Third, the pin placement is important. It should never be attempted without a roentgenogram which outlines the pulp chamber. By studying pulp-chamber form, we may conclude that the best place to have the pin is beyond the horn of the pulp or, if the case does not necessitate an extensive incisal restoration, between the horns, which is a low point in the incisal pulp form. Fourth, when the placement of the pin has been determined and the pinhole prepared, the cavity outline should be extended a little beyond to permit the pin to be completely embedded in the filling. Fifth, the bevel should be continuous for the full perimeter of the cavosurface angle, with special attention to the rounding of the sharp corner which occurs at the enamel margin of the step to prevent fracture of this delicate area in fitting and seating the inlay, and to allow for sealing.

The Class IV lingual lock has some variations which must be kept in mind: First, the lack of harmony in preparation will cause a distortion in the pattern or impression as it is removed, and if the distortion is too great, the preparation

cannot be used without alteration; or if the distortion is not too great to eliminate its use, at least a good deal of the detailed form of the cavity so painstakingly created is lost. Second, if there is lack of harmony in the walls and the correction is attempted by straightening the incisal wall of the lock portion, a good deal of the retentive form is lost, and much more cutting than is necessary has to be done. Third, we should have a mental picture of the cross-section of the tooth when cutting the floor of the lingual lock so that the plane of the floor will be kept in the same plane as the external area, this allowing adequate protection of the pulp and sufficient depth of preparation for a serviceable restoration. Fourth, the age of the individual for whom the restoration is being made or the evidence of lack of secondary deposit may necessitate altering the depth and depending upon a more extensive area to gain retention and to safeguard the pulp.

The use of the baked porcelain inlay for this class of cavity is in my opinion limited to selected cases in which the forces to be applied are minimum. The retentive form should be generally the lingual lock type because the use of pins, which must be baked in, does not give much strength. In fact, it is the belief of many operators, and supported by clinical evidence, that it tends to weaken the inlay as fracture frequently occurs at the site of the pin. The care of labial margins, the elimination of the sharp angle and the bevels and the provision of good bulk should be carefully adhered to.

The use of silicate is contraindicated except as stated previously in combination with gold. Either as a protecting skeleton casting or as the so-called window inlay where a complete cast gold inlay is constructed, and either in the wax pattern or after the completion, a portion of the labial surface is removed and silicate placed purely for the esthetic effect. Sometimes, as a temporary measure, the whole incisal corner is restored with silicate. In this case, one or more iridioplatinum pins are used to reinforce it. The pins are placed one near the incisal portion and possibly one or two in the gingival portion, the pins being cemented in first and then the silicate restoration made about it.

The Class V, or gingival, cavity is the one that I like to refer to as the hypocrite. It looks so simple, but it is one which causes a good deal of difficulty. All of the common restorative materials are used in this cavity. One of the difficulties encountered is common to preparations for all materials; that is, depth. We are aware of the relationship of the structures at the point where these cavities occur, and, because of this, we commonly make one or two errors: First, in an effort to get adequate pulp protection, the central portion is entered deeply enough, but if the floor is cut straight across, there is no mesial and distal wall resistance. If, in an effort to get sufficient mesial and distal resistance, the cavity floor is cut straight across the central portion too deeply and the pulp is endangered, the correction of this fault is to cut the cavity floor on the same curve as the external form of the tooth at the site of the cavity.

The cavity prepared for gold foil is beveled on the entire circumference of the cavosurface, the retention form being placed in the four point angle started with a small inverted cone and accentuated with line anglers. Convenience starting points are employed if necessary. If the cavity is small, the whole wall may be undercut. The only difference for amalgam is that the bevel is on the cervical portion only and no convenience points are necessary.

The preparation for silicate is the same as for foil except that there is no bevel, and the retention form is rounded instead of being so sharp as for foil. The

preparation for the cast gold inlay has the bevel used in gold foil, but again the walls, as in other inlay preparations, must be flared slightly.

The baked porcelain inlay is prepared as the cast gold is except that there is no bevel. The preparation of this cavity, as long as it is not too extensive, does not offer any great difficulty except that it is usually in a hypersensitive area, and a definite preparation is difficult unless local anesthesia is resorted to.

One of the most annoying difficulties of this type of inlay restoration is the tendency to become unseated, due to the vibration set up as the teeth occlude, the tendency being to jar the inlay out. There are two suggestions for overcoming this: First, in the cavity preparation, the gingival wall is prepared with a round bur so that a lock is created when the inlay is rotated to place. Second, after the restoration is completed, just prior to setting, a small knife-edged stone is used to cut a groove in the walls of the prepared cavity and a corresponding groove around the circumference of the inlay; the idea being that the cement will thus have a key way into which to flow, a more definite lock resulting than when the irregularities of the inlay and cavity wall are depended on.

When the cavity is so extensive that it is difficult to have a distal or labial wall, much resistance and retention are lost, and the preparation must be varied to supply them. The best way is probably the use of pins placed in the dentin on each side of the pulp. The outline of the cavity is made, then a No. ½ round bur is used to make a pinhole for a number 24-gage iridioplatinum pin 1.5 to 2 mm., and these are cast in the gold inlay or baked in the porcelain inlay, after the pin has been roughened. A good way to roughen these pins is with a jeweler's die plate, through which the wire can be threaded. Because of its small gage, it is difficult to roughen the wire by ordinary means. A variation of this technic of the use of pins with the cast gold inlay is the cross pinning during the process of setting the inlay. In this case, after completion of the inlay, the position that the pins are to take in the dentin is determined and, with the No. ½ round bur, holes are drilled through the inlay and into the dentin, the pins diverging. Then, as the inlay is set, the pins are put in place, cut off and spun or riveted down, and the area is sealed.

As we have talked of preparations and restorations, the idea of fit that comes to mind is probably the approximation of the margins of the inlay to the margins of the cavity, and with an inlay restoration, the approximation of the internal surfaces of the inlay with the internal cavity surfaces, but before closing the discussion I should like to bring to mind the fact that a little deeper reflection impresses us with the idea that fit, or "biologic fit," as we like to think of it, involves more than that. It involves a restoration based upon the concept that our work in operative dentistry should be biomechanical, that we should do it with an appreciation of the significance of the other sciences, such as anatomy, histology, physiology, bacteriology and pathology. It involves an inlay which fits in the sense that it belongs where it is because it takes into account all conditions. As an example, an inlay made with an exacting cavity preparation and a very careful casting technic, and finished with beautiful margins, may be a failure, if we have failed to restore function.

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FRACTURES OF THE MANDIBLE

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SINCE the advent of oral surgery as a specialty, fractures of the mandible have been extensively and minutely studied, in an attempt to improve both technic and results. Of recent years, the trend has been in the direction of simplicity, not only simplicity of operation for the surgeon, but also simplicity of procedure for the patient. This trend has not caused end-results to be sacrificed one iota.

The original principles of treatment of all fractures as outlined by Hypocrates must still be followed religiously. These principles were very simple, but also very demanding. They were: first, place the fragments in correct apposition; second, retain the fragments in this position until union takes place.

Although these rules have not changed, the mode of treatment has been in a constant state of evolution, progressing from complexity to simplicity, from the unscientific to the scientific and from crudeness to finesse. By this very evolution, results have been vastly improved.

To give us a background for the ensuing discussion, I shall digress for a moment to discuss some of the peculiarities of the anatomy of the area that influence fracture diagnosis and treatment.

The mandible is the only bone of the skull that is movable upon the others. It is a hard, brittle bone and ordinarily fractures in a fairly straight line with little tendency to comminution. This tendency to fracture in a fairly straight line is due largely to the presence of the teeth in the jaw bone, comminution being much more common in an edentulous fracture. The anatomic form of the bone itself determines in part where the bone shall break, the factors being: (1) the teeth (including impacted third molars); (2) the mental foramen; (3) the mandibular foramen, and (4) the neck of the condyle. Other considerations are, of course, the severity of the trauma and the direction in which it is applied.

Displacement of the fragments may or may not take place. Displacement occurring in the beginning (primary) is caused by the original act of violence. If it comes about gradually, it may be termed secondary. This secondary displacement, instigated by muscular action, will always take place unless there is a definite counteraction, which may be supplied by early immobilization, beveling of the fracture line or interdigitation of the fragments.

The muscles that enter into the problem of displacement are roughly classified as elevators and depressors. The elevator group includes the masseter, internal pterygoid, temporal and buccinator. The depressor group is made up of the geniohyoid, genioglossus, platysma myoides and digastric.

Examination of the muscles in this grouping will show that the elevators are grouped in the posterior part of the mandible and the depressors in the anterior. As a result, the fragments will, without counteraction, be drawn up in the posterior portion and downward in the anterior portion. The pull toward the midline is supplied by the mylohyoid muscle.

Displacement can be corrected by

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manipulating the fragments into normal position, with retention in that position by interdental ligation; or it may be simply and easily reduced by elastic traction. The adoption of intermaxillary rubber-band traction has been a long step in the right direction. It has meant a procedure more easily endured by the patient, and certainly is productive of greater comfort during the period of convalescence. Mouth hygiene can be kept on a high plane during the period of immobilization, since the elastics can

Fig. 1.—Darcissac method of controlling posterior edentulous fragment. Elastic traction is used if complete reduction cannot be accomplished at the time of operation.

be removed periodically to allow cleansing of the area surrounded by the teeth. Traction can be so adjusted that some motion is allowed if desired. It is routine in my cases of fracture of the condyle alone to apply only enough traction to bring the occlusion back to normal at rest. With this arrangement, the patient is allowed a soft diet, with all of its obvious benefits.

More important than all of these advantages, however, is the simple fact that results are much better when traction is correctly applied. Fractures that could not be completely reduced by manipulation can now be slowly, easily and painlessly reduced by gradual traction.

The problem now arises as to how the traction shall be applied. The only prerequisite is fixation of lugs on a sufficient number of teeth in all fragments. These lugs can be supplied by any one of several methods, employing (1) aluminum disks, (2) wire arch bars or (3) Stout's multiple loop appliance.

The aluminum disks and arch bars have been standard equipment for some time, and both have been popular and useful. Stout's multiple loop appliance, which is of fairly recent development, offers many advantages over the disks and bars. It is strong, inexpensive, simple and rapid of application, and does not retain food particles. It is indeed a valuable contribution to the treatment of fractures.

Elastic traction for reduction can be used on any fragments that bear teeth. It can also be used in immobilization of the mandible after fracture of the condyloid process.

All fractures of the condyle can be handled in this manner. Displacement of the head medially and anteriorly is expected, being due to the contracture of the external pterygoid muscle. The fractured part is drawn completely out of action and a new joint is formed; in many cases, by the rounding off and eburnation of the bony stump. Open reduction is not only unnecessary, but also dangerous. Treatment should consist of only enough elastic traction to bring the teeth to normal occlusion when at rest. Complete immobilization is not required. If a condyle is broken off and the lower jaw is completely edentulous,

the problem is, of course, magnified. In such a case, it is well to place the patient under observation for a time. If no deformity ensues, no treatment is necessary. If a shift to the affected side develops, reduction is necessary. It can be accomplished by placing a wire around the symphysis of the mandible; and anchoring the wire to a post attached to a previously constructed head cast. This wire will prevent or correct any foreshortening of the affected side. The use of elastic traction is therefore seen to be limited to tooth-bearing fragments and to the treatment of fractured condyles.

Fig. 2.—Intra-oral splint used where displacement is not marked. This method will control the posterior fragment.

The problem of what to do in the fracture of the edentulous mandible or in fractures posterior to the last tooth is still one which causes much concern. Many practitioners would say that the treatment of the fractured edentulous mandible has been completely solved by the use of circumferential wiring. Its many disadvantages, however, to my mind outweigh the single advantage of simplicity of treatment. To draw up a circumferential or circummandibular wire tightly enough to immobilize fractured bone will very often mean ulceration of the mucous membrane of the ridge under the denture. If it is not drawn up tightly and the ridge is shallow, as it often is, displacement may take place secondarily. At any rate, when this procedure is carried out, the lower denture or splint is wired in place for the duration of treatment. Food collects and decays beneath it, and the result is not pleasant. Therefore, I have completely abandoned this mode of reduction. If the fracture line in an edentulous mandible is at such an angle as to discourage secondary displacement by muscle traction, the case can be followed without immobilization, usually to a successful conclusion.

If, however, there is primary displacement from the force of the original blow or if the angulation of the fracture line is such as to favor secondary displacement, reduction is accomplished by open operation and direct ligation of the fragments. Infection in these cases has been

eliminated largely with the advent of chemotherapy. When open reduction is performed, sulfanilamide powder should be placed in the area. If there has been a communication with the mouth, provision for drainage should be made. If not, the wound can be tightly closed.

The advantages of this method can be listed as follows:

1. It is certain to have good results if correctly performed.
2. It permits immediate use of his jaw.
3. It assures postoperative comfort.
4. There are no encumbrances either intra-orally or extra-orally.

Critics of the method say that it is too difficult a procedure; that there is danger of postoperative infection, and that it produces an unsightly scar on the face. To this, I would answer that if the case is correctly handled, all these difficulties can be eliminated or reduced to the minimum.

It must be immediately assumed that we are to follow Hypocrates' principles in deciding on the treatment. We must insist that the fragments be brought into apposition and be held so until union takes place. It is just as correct for the oral surgeon to perform an open reduction operation upon a mandible, when indicated, as it is for an orthopedic surgeon to directly wire a patella, which is considered a justifiable procedure.

It is not difficult: to the contrary, it is very simple. The fragments are brought into direct view by the dissection, and they can therefore be completely approximated.

The incision should be carefully placed so that when the dissection is carried down to the bone, an equal amount of each fragment is available. To do this, the x-ray and clinical examination must be concise and complete. Excessive ex-

Fig. 3.—Case in which fracture through body of edentulous mandible has been cared for by direct wiring of the fragments. The fractured condyle required no treatment whatsoever beyond observation. Any deviation resulting from the condylar fracture could have been cared for by a circumferential wire at the symphysis anchored to a post from a head cast.

posure and excessive stripping of the periosteum is not conducive to uneventful healing. The drill holes should be kept about a centimeter away from the fracture line and the wire should be of a fine gage.

Hemostasis must be complete before closure of the wound, to prevent formation of a hematoma in the incision. The periosteum is carefully approximated and the remainder of the incision closed in layers. Either an interrupted or a continuous intracuticular stitch is used prior to the placing of the final skin sutures. These skin sutures must be fine and non-capillary and must be placed on a non-traumatic needle. If all of these rules are followed meticulously, a satisfactory result is to be expected.

Fractures posterior to the last tooth are among the most difficult to handle. Here again, the angulation of the fracture line influences the type of treatment. If there is no primary displacement and the angulation is such as to oppose the muscles, simple immobilization of the mandible is sufficient. If there is primary displacement or the angulation favors displacement, a different course of action must be followed. The types of treatment in this situation are: 1. Direct wiring of the fragments. 2. The use of intra-oral splints. 3. Retention of a tooth in the fracture line until callus formation is sufficient to prevent displacement. 4. Method of Darcissac.

Each type has its own indications, although no definite rule can be laid down for the use of any one. In general, if the posterior fragment is a long one, such as from the cuspid on back, and if the fracture line has not been grossly compounded into the mouth, direct wiring of the fragments is carried out. Usually this is supported intra-orally by light elastic traction. If the fracture is at the angle and there is little or no displacement, and most of the teeth are present, an intra-oral splint is used, consisting of a half-round bar, fastened to the teeth with orthodontic bands. As it passes the posterior teeth, it dips downward, so that when it is in place, it will engage the anterior surface of the ramus. A small stab wound in the area of contact at the ramus is made so that the bar directly engages the bone.

Occasionally, the fracture line will pass through a fully erupted third molar tooth, and it may extend in such a direction that if the tooth were removed, displacement could be expected. In such cases, it is perfectly justifiable to allow the tooth to remain in place for about two weeks or until sufficient union has taken place, and thus prevent displacement; or the tooth can be extracted and one of the previously described splints be applied.

However, if the fracture line extends through the angle and there is marked displacement of the ramus, the method described by Darcissac is the one of preference. In such cases, a plaster of Paris head cast with a bar incorporated is placed before the operation. The bar extends from the head cast downward and posterior to the angle of the mandible. The angle of the mandible is then exposed and a drill hole placed through the bone. Silver wire is threaded through the hole, and after the fragment has been pulled back to its correct position, it is held there by ligating the wire to the post. The incision is closed in layers and sulfanilamide powder is deposited in the wound under the periosteum. In old fractures or impacted fractures, where it is difficult to bring the fragment down, displacement can be corrected with elastic traction between the silver wire and the post.

Of course, the age and the condition of the patient, and other complicating factors, must be considered before a decision is reached as to the type of reduction to be used. Many patients having fractures of the mandible have additional injuries, and it is often necessary to wait as long as a week or ten

days before reduction. If a general anesthetic is contraindicated, even open reduction can be carried out under local anesthesia if adequate preoperative sedation is used; or intra-oral ligation of the bone fragments can be carried out if displacement is not marked.

As we all know, no clearcut rule can be laid down for reduction of each type of fracture. Instead, it is a wiser policy to consider each case individually and consider all facts carefully before a decision is reached.

It is of supreme importance that we consider these edentulous fractures and edentulous fragments with the utmost care. They present a difficult problem, it is true, but it should be faced with resolution. No halfway measures are acceptable if we are to treat our patients honestly.

Henry Ford Hospital.

ACRYLICS: THEIR PRESENT STATUS AND TECHNICS AS APPLIED TO CROWN AND BRIDGE PROSTHESIS*

PART II

By STANLEY D. TYLMAN, M.S., D.D.S.,† Chicago, Ill.

A YEAR ago, I submitted a progress report on the uses of acrylic resins in crown and bridge prosthesis. Confusion existed at that time in the minds of many, and conflicting statements were made relative to the various materials then available, also in regard to the various technics employed in the manipulation and processing of the resins. The enthusiasm for acrylics sweeping the profession constituted a threat to the continued use of gold and porcelain. A few men were not swept off their feet, but were willing to study and investigate the possibilities of the new material. They were sufficiently interested to study the physical properties of the synthetic resins, also both the possible extent of their clinical application and their behavior. During the intervening twelve months, several groups of investigators and teachers have conducted extensive investigations, both physical and clinical, and this symposium is only one of the several progress reports that are being made on the study of synthetic resins.

More complete information regarding the behavior and uses of these materials can be obtained by studying the bibliography of this paper.

Although the synthetic resins, particularly the methyl methacrylates, have definite limitations so far as their use in crown and bridge prosthesis is concerned, their application in complete denture prosthesis is sufficiently successful and encouraging to suggest a further study in their uses for smaller restorations.

Of the several types of synthetic resins available, the methyl methacrylate polymer, when used either with the mono-

*This paper and the one by Drs. Peyton and Mann on acrylic and acrylic-styrene resins were presented as a symposium on acrylics.

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Read before the Section on Partial, Crown, Bridge and Full Mouth Reconstruction at the Seventy-Eighth Annual Midwinter Meeting of the Chicago Dental Society, February 25, 1942.

meric methyl methacrylate or the monomeric styrene, seems to be the material most suitable for the smaller restorations. During the past year, three to four reputable manufacturers have produced an improved acrylic polymer which possesses the necessary fineness, color and working qualities to enable the average dentist to reproduce colors and shades with a remarkable degree of accuracy. The acrylic kits also contain several modifying colors so that the basic students can have fairly satisfactory results in using the material.

A year ago, we questioned the suitability of the newer synthetic resins for crown and bridge prosthesis on the basis of their physical properties and their ability to sustain the conditions to which they would be subjected in the mouth. At that time, we questioned the hardness, low modulus, cold flow, water absorption and dimensional changes to which these materials were subjected, and pointed

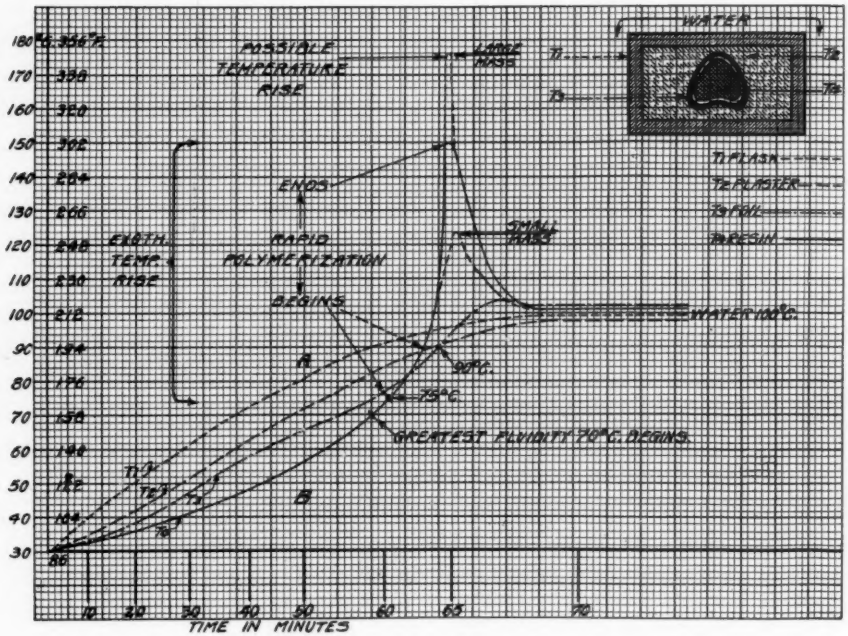

Fig. 1.—Chart prepared by the author in collaboration with W. Barteau, based on experiments conducted at the University of Illinois College of Dentistry and showing relative temperatures of the resin, investment, tin foil and heating medium.

body and incisal colors may be either intensified or diluted. The kits also supply a monomer of either methyl methacrylate or styrene. A recent development in the color reproduction enables the operator to give the acrylic resins a fluorescence comparable to that of natural teeth.

With reasonable care, even dental

out the possible deleterious effects that might accompany such changes when acrylic prostheses were placed in the mouth.

In the report submitted by Dr. Peyton, it was shown that in the acrylic resins which were processed for at least sixty minutes in boiling water, the Brinell hardness number compared favorably

with that of 24-carat cast gold. Some investigators, however, question the validity of a Brinell test for acrylic resins. A year ago, this information had not been definitely ascertained owing to the fact that the processing time employed was usually too short. It is readily seen, therefore, that on the basis of hardness, acrylic resins properly processed can be safely used in gingival third and in simple occlusal inlays, also as veneers for complete veneer cast gold crowns.

It is further evident from Peyton's studies that the polished surface of a properly processed acrylic resin offers greater resistance to scratching than does 22-carat gold. There should be no hesitancy, therefore, in the use of this material in protected areas where the possibility of scratching is small.

It may be recalled that a year ago the question was also raised as to whether, upon removal of the testing load or stresses that might be applied during mastication, there is an immediate and a complete elastic recovery or whether the resulting cold flow remains as a permanent deformation. Owing to the possibility of such a deformation as either a temporary or a permanent condition, it was suggested at that time that all bridges be reinforced with a metallic truss.

The work of Peyton and his associates

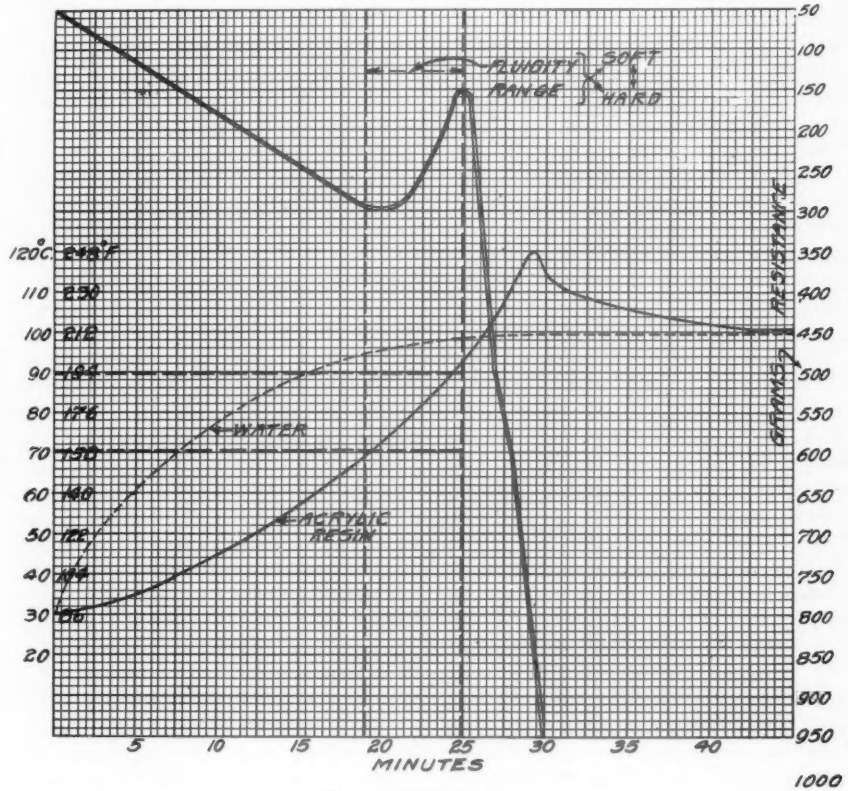

Fig. 2.—Fluidity ranges.

indicates that even though a recovery of elasticity follows the removal of the load from the resin, this recovery is not complete inasmuch as a permanent distortion remains. This finding of Peyton is based upon the application of a static load of 3,550 pounds per square inch applied for seven days continuously. It would be interesting to know what, if any, would be the permanent distortion of this material if loads comparable to those of the stresses of occlusion were applied intermittently over a similar period of time. The question is raised as to whether such permanent deformation is cumulative under these conditions.

Clinical experience indicates that the acrylic resins possess the necessary toughness or resistance to impact force, provided there exists a sufficient bulk of material, and that no shearing planes are effective.

The greatest obstacle at present to the more nearly universal acceptance of the acrylic synthetic resins for operative and crown and bridge restorations is found in the dimensional changes that the material undergoes during processing and subsequently to its placement in the mouth. It has been shown by Sweeney, Paffenbarger, Peyton and others that a linear shrinkage of 0.30 to 0.53 per cent occurs during the processing of acrylic resins. It is also recognized that this shrinkage is not always uniform throughout the prosthesis because of its variation in size, shape and cross-section.

In addition to this initial shrinkage, it is found that the processed acrylic, if exposed to the air to dry for extended periods, will exhibit a further shrinkage, even to 50 per cent of its total shrinkage, as shown by Peyton. The latter shrinkage is more apt to occur if the processing has not been continued over a period of from sixty to ninety minutes after the boiling point of water has been reached. In a further effort to control this shrinkage and to reduce it to a minimum, we originally suggested that the electrodeposited copper die be employed instead of the cement or stone dies.

As previously mentioned, an acrylic resin shrinks when exposed to air, but when placed in water it may expand approximately 0.8 to 1.0 per cent within a period of twenty-seven days. That the acrylic resin may absorb water and expand nearly 1 per cent and the usefulness of a complete denture not be affected does not necessarily mean that similar dimensional changes are without danger in less extensive restorations, as in fillings, crowns and bridges. In the complete denture, the mucosa adapts itself to the conditions necessary, whereas, in less extensive restorations, when the acrylic is in direct contact with hard, unyielding and unaccommodating tooth tissues, the dimensional changes, even though small, may prove disastrous. Clinical experience has shown that an acrylic crown which in its dried condition was cemented to the prepared tooth loosened in a very short time owing to water absorption and the accompanying expansion of the crown, which resulted in breaking away of the cement. The same observation has been made with anterior three surface restorations. Because of this dimensional reaction of resins to moisture, it is recommended that crowns and other small acrylic prostheses before being cemented be kept submerged in water. The National Bureau of Standards has shown that, at the end of ten days, the expansion is approximately 0.75 per cent.

Since the available expansion due to water absorption may be nearly 1.0 per cent, and since the shrinkage of processed acrylic resin is approximately 0.5 per cent, it should be possible to produce a prosthesis of plus dimensions before cementing it to place. When styrene is used instead of methyl methacrylate as the monomer, the percentage of water absorption is reduced, with an accompanying reduction in the expansion of the appliance.

In a previous paper,[2] I discussed the

four methods used for mixing and using the polymer and monomer. At that time, I also presented and explained the processing chart (Fig. 1), which was originally prepared and first shown at the Houston meeting of the American Dental Association. While it is recommended that one hour be consumed in raising the temperature of the acrylic to the polymerization range and then that it be maintained at 212° F. for at least sixty minutes, the studies of Peyton indicate that the latter time could be increased to ninety minutes with advantage. This increased time is especially desirable if the flask is not given a gradual "run-up" heating period.

The chart in Figure 2* shows the fluidity curve of the acrylic material during processing. It indicates in grams the resistance of the material to displacement under a load. Of the two lower curves commencing at 30° C. (86° F.), the bottom solid-line curve represents the reaction of the acrylic resin and the middle broken-line curve represents the temperature rise of the heating medium, water. The upper double line curve indicates the increased resistance of the acrylic material to displacement as the temperature of the acrylic is raised. This increase in resistance to displacement is first characterized by a gradual hardening of the mass, in this instance during the first twenty minutes or until the acrylic reaches the threshold of the fluidity range at a temperature of 70° C. (158° F.). It will be observed that, at this point, the downward path of the curve stops at 300-gm. resistance, then reverses itself during the next eight minutes, indicating a reduced resistance to displacement, or a gradual softening of the acrylic material until it reaches 90° C. (194° F.), or a point of resistance of 150 gm. The curve then drops sharply so that within five minutes it reaches a resistance of nearly 1,000 gm. It may be noted that this approaches closely the crest of the exothermic curve; which may help to explain further why complete closure of the flask is recommended during the short interval of time when the temperature of the acrylic material lies in the 70 to 90° C. (158 to 194° F.) range.

During the range of greatest fluidity and the period of complete polymerization, a skeletal framework of molecules, or "elastic memory," is created which is determined by the shape of the mold in which the restoration is processed. This skeletal molecular structure is permanent and the characteristic of each individual restoration. Any effort or technic which subsequently disturbs or displaces this molecular structure will set up internal strains, which ultimately result in a distortion and misfit of the appliance, because the distorted molecular structure is constantly trying to resume its normal, original form.

Clinically, the acrylic restorations have proved themselves to be biologically compatible if the tooth has been properly prepared, and if the restoration itself conforms to the same physiologic and mechanical requirements demanded of the standard types of gold and porcelain restorations. Apparently, the absorption of water by the acrylic material does not react harmfully on the contiguous tissues. One of the objectionable features noted is a slight tendency of the material to become stained. This, however, may have been the result of improper processing.

The acrylics are not resistant to abrasion when they are opposed by ground porcelain teeth or by natural teeth whose surfaces are not smooth and rounded. Our observation has been that an acrylic tooth in contact with an acrylic prosthesis in the presence of saliva does not undergo any material change or mechanical abrasion.

The other objection raised, that crowns

*Prepared in collaboration with Drs. F. Bazola and E. Ragan of the University of Illinois.

made of acrylics are more likely to become displaced because of the elasticity of the material, may also be overcome by proper preparation of the cavity or tooth.

One of the annoying and perplexing problems with acrylics is that of porosity. Porosity usually occurs in thick specimens containing a large volume of material, but it is sometimes a quality of the less bulky restorations.

As shown in the time-temperature processing curve (Fig. 1), when the acrylic resins reach the 70 to 90° C. (158-194° F.) range, the temperature rises precipitously within a short period of time; in a few minutes, to be exact. When a large amount of acrylic is involved, polymerization, even though rapid, starts from the outer surface and progresses inwardly. When the temperature on the outer surface exceeds 100.3° C. and there remains free monomer within the center of the mass, it is possible for the monomer to be volatilized and the gas so formed to be trapped and inclosed within the polmerized mass. It has been found advisable that, as the volume of acrylic increases, the time of processing be lengthened and often at a lowered temperature.

High temperatures produced during the initial stages of polymerization, or when complete dispersion of the monomer in the polymer has not yet taken place, may also cause the monomer to be volatilized and produce bubbles which are trapped within the finished polymerized structure.

In order to control and reduce the excessive exothermic rise during the polymerization of acrylics, several different temperature and time schedules have been recommended. It has been suggested that instead of raising the temperature of the water to 212° F., it be brought to 160° F. and kept at that point for a period of three hours. Polymerization also occurs and the exothermic curve is flattened out, and thus the possibility of gas and bubble formation is reduced.

Porosity has two definite disadvantages: (1) it weakens the structure in its resistance to stresses and (2) the minute bubbles produce a dispersion of light, which changes or modifies the color of the acrylic material. In clear acrylic material, this produces a milky or cloudy appearance in the finished denture, similar to that caused by exposure of the resin to water during processing.

During the past year, the disappearance and dissolution of inlays, crowns and other types of acrylic prostheses in the mouths of patients who were given ether have been reported. When an acrylic prosthesis is placed in a container of ether, it gradually softens to the degree that the entire crown or inlay may be twisted out of shape without breaking. When such a crown is removed from the container and the ether is allowed to evaporate, the crown again hardens. Upon prolonged immersion and subsequent drying in the air, the crown will craze or crack, but apparently with no loss of substance. The crazing effect has also been noted when strained specimens are exposed to alcohol. When confined within a flask containing ether fumes, the crown will likewise soften, but at first only superficially. The depth of such penetration and softening is in proportion to the length of time that the crown is subjected to the ether fumes.

Therefore, it is recommended in those patients who are to be given ether that the prosthesis be covered with an impervious lacquer or with a thick layer of heavy lubricant, as a buffer and for protection of the crown during the time that the anesthetic is administered.

When an acrylic veneer is employed with a complete cast gold crown or metal trusses are used in reinforcing acrylic bridges, the problem arises of masking the metal so that it will not show through the acrylic. In an effort to overcome this difficulty, several of the reliable manufacturers have prepared an opaque

polymer, which is mixed with monomer, the thin mixture being applied to the metal surface while hot. The hot metal volatilizes the free monomer and a thin opaque coating is left over the metal. The body and enamel colors are then applied without danger of modification of the color by the presence of the metal.

When instead of the electrodeposited copper die, a plaster or stone model is used in constructing inlays or crowns, the removal of the plaster from the polymerized prosthesis is often a serious problem. Removing plaster or stone from the fine margins of an inlay, or near the outer margins of a veneer crown, may prove disastrous if the crevice is deep and the stone or plaster is quite hard.

To overcome this difficulty, Clyde Nelson offers the suggestion that the prostheses be dropped in a solution of sodium citrate after the bulk of the plaster or stone has been removed. The proportions are 1 teaspoonful or 4 gm. of the sodium citrate crystals to approximately 2 ounces of water. The prosthesis is left in this solution for several hours or until such time that the adherent stone or plaster may be washed away with a brush under running water. This suggestion should prove of value.

One of the most frequent questions is "What cement is most satisfactory for cementing acrylic prostheses?" Some use silicate cements, some kryptex. Others use the regular zinc phosphate cements. Our experience has been that while it may be advantageous from the standpoint of color to use the silicate or kryptex cements, the fine crystals in the zinc phosphate cements seem to offer the best cementing medium. The suggestion has been made to mix the zinc phosphate cement with 15 per cent of the silicate, for a more translucent cementing medium.

In conclusion, it must be remembered that we are dealing with a comparatively new material applied to new uses. That the synthetic resins have their limitations is readily admitted by those studying their physical properties and clinical applications. The correct approach is not an effort to replace all other dental materials with it, but the determination by scientific study and clinical observation of its rightful uses and limitations in dental practice.

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ACRYLIC AND ACRYLIC-STYRENE RESINS: THEIR PROPERTIES IN RELATION TO THEIR USES AS RESTORATIVE MATERIALS*

PART I

By F. A. Peyton, D.Sc., and W. R. Mann, D.D.S., M.S., Ann Arbor, Mich.

INTRODUCTION

THE use of synthetic resins as restorative materials is probably the most discussed topic in dentistry at the present time. Such discussions are primarily concerned with the correct methods for processing the various products now available, together with considerations of the variation in their composition and characteristic properties.

Within the past few years, acrylic resins have been accepted as a suitable base material for complete and partial denture prosthesis. The use of resins for this purpose has been well described in the numerous articles that have appeared at frequent intervals in the current dental literature.[1] More recently, it has become apparent that, in the future, synthetic resins may have an even more extensive use in accepted operative and prosthetic dental practice. At present, however, there is a lack of definite information as well as little correlation of the properties and behavior of the resins when used for inlays, crowns, and bridges. The available literature deals principally with the various technics by which these inlays, jacket crowns, bridge pontics and similar restorations are constructed from synthetic resins.

Because such a situation exists, this study was undertaken, for the purpose, first, of comparing the properties of methyl methacrylate resin with those of the methyl methacrylate-styrene combination; second, of comparing the effect of different processing methods on the finished product, and, third, of correlating the properties of each material with the various restorative applications for which the resins are used.

CHEMISTRY

By way of introduction to the general chemistry of resins, it is well to recall that, while methyl methacrylate and methyl methacrylate-styrene resins seem to be the most popular materials for restorative purposes at the present time, Skinner[2] and several others have suggested that there may be unheard of possibilities not yet discovered. This appears probable in view of the numerous resins that have been introduced and discarded during recent years.

As used at the present time, all tooth restorative resins are supplied in powder and liquid form, as are many of the popular denture base resins. The powder portion is commonly referred to as the polymer (many monomer molecules linked together to form giant molecules) and the liquid as the monomer), a single molecule which when heated or other-

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*This paper and the paper by Dr. Tylman on acrylics were presented as a symposium on acrylics.

Read before the Section on Partial, Crown, Bridge and Full Mouth Reconstruction at the Seventy-Eighth Annual Midwinter Meeting of the Chicago Dental Society, February 25, 1942.

wise treated combines with other similar single molecules for polymerization.

Many of the popular denture base materials consist of methyl methacrylate polymer and monomer. So far as is known, all but one of the tooth restorative resins are of this fundamental composition. This one resin consists of a methyl methacrylate polymer (powder) and a styrene monomer (liquid).

On mixing the powder and liquid, a plastic mass is formed. It is believed by some that the methyl methacrylate powder is dissolved to a lesser degree in methyl methacrylate liquid than it is in the styrene liquid. Thus, a solid undissolved central core of each powder particle remains after the mass has become plastic. This may or may not be true. In either case, when this plastic mass of methyl-methacrylate powder and liquid is processed by any of the accepted technics, polymerization (the act whereby the material of lower molecular weight is built up to that of higher molecular weight, but of the same percentage composition) is considered to take place. When the styrene monomer is used, the processing operation is referred to as copolymerization (the act whereby more than one type of material is polymerized or combined simultaneously). Little definite information exists on the properties of the methyl methacrylate-styrene copolymer. It has been observed frequently, however, that a copolymer has properties which are different from, and sometimes an improvement over, those of either original ingredient. Usually, these properties are intermediate between those of the reacting resins.

MATERIALS

The products included in this study are listed alphabetically in Table 1. Included are four resins considered typical of those used for tooth restorative purposes, together with one denture base material. These products were the most popular when this work was started, although numerous other products are now available for the same purpose. In Table 2 are listed some of the manufacturers' claims for these products. It is seen that all except enameltone consist of methyl methacrylate monomer and polymer. It can be assumed, therefore, that the properties of all the resins of this composition should be essentially the same. For this reason, crystolex, a denture base material of the methyl methacrylate type, was used freely for comparative purposes.

SHELF LIFE OF POWDER AND LIQUID

The work of Sweeney[3] shows that, for many well-known products, there is no change in working qualities of methyl methacrylate powder and liquid intended for denture base uses after being stored at room temperature (25±5 C.) for more than a year. In this study, the powder and liquid for both acrylain and acrynamel have been observed for nine months without any apparent change. The methyl methacrylate powder supplied for enameltone likewise has remained free from change in behavior for more than a year. It was noted occasionally than the styrene liquid of enameltone polymerized at room temperature. This may be due to contamination or to prolonged exposure to light and air. The life of the liquid may be lengthened, however, by keeping the container stored in a cool, dark place. The distributor, in a private communication, has stated that recent improvements in the

TABLE 1.—PRODUCTS STUDIED

Brand	Distributor	Address
Acralain	Acralite Co., Inc.	New York, N. Y.
Acrynamel	H. D. Justi & Son, Inc.	Philadelphia, Pa.
Crystolex	Kerr Dental Mfg. Co.	Detroit, Mich.
Enameltone	Nelson-Kramer Corp.	Royal Oak, Mich.
Vitain	Cosmos Dental Products, Inc.	New York, N. Y.

purity of the liquid styrene prevent much of this difficulty.

PHYSICAL AND MECHANICAL PROPERTIES

In order to determine the physical and mechanical properties of these resins, it was necessary to adopt some standard processing method. Various technics have been suggested, including such extremes as 150-175° F. for one hour in water to 280° F. for one hour in a steam vulcanizer. Longer and shorter intervals of time likewise have been recommended.

For comparative purposes, the products in this study were processed for sixty minutes in boiling water. This method was chosen because, from a practical standpoint, it is simple to apply and in all probability is the method most extensively used in the dental office at the present time. The details are given in the section on linear shrinkage during processing.

A part of this study, which is not yet completed, deals with the changes in physical properties which occur as the processing interval in boiling water is varied from thirty to ninety minutes. Complete data for this phase of the problem have been obtained for the methyl methacrylate styrene resin (enameltone), but are incomplete for the methyl methacrylate resins. It may be supposed, however, that variations will take place in the methyl methacrylate resins which are in general similar to those that occur in the methyl-methacrylate styrene product.

It is believed that the high temperatures generally developed in the vulcanizer are unsuited to the processing of these resins. Possibilities of color change as well as porosity and other physical changes are greatly increased at these high temperatures.

All test samples in this study have been prepared by compression molding rather than by injection molding methods. This practice seems to be justified on the basis of the belief held by many practitioners that blending and shading can be more easily controlled by this process than by injection molding. Furthermore, it appears that the published data available at this time are insufficient for a conclusion that the properties of the final structure differ appreciably owing to the method of molding. Studies of this phase of the problem will probably prove both interesting and valuable.

TABLE 2.—MANUFACTURERS' CLAIMS

Brand	Composition		Properties
	Monomer	Polymer	
Acralain	No advertised claims—(presumably methyl methacrylate)		Impact strength to resist functional stress, stay clean; non-absorbent
Acrynamel	Methyl methacrylate (Rohm & Haas Co.)	Special acrylate powder	Greater impact strength than human teeth; finer particle size than other resins
Crystolex	Methyl methacrylate monomer and polymer (Rohm & Haas Co.)		A denture base material, not subject to inlay use.
Enameltone	Styrene monomer—methyl methacrylate polymer		High impact strength, tough and resilient; resists breakage; does not shrink during processing.
Vitain	Advertised as blended acrylic (presumably methyl methacrylate)		Unusually high strength; greater impact strength than porcelain; non-porous and non-absorbing

DIMENSIONAL CHANGE

With the foregoing method for processing and molding the samples, a number of physical and mechanical properties of the resins were measured. The first,

and perhaps one of the most important of these properties, is the dimensional change that occurs during and subsequently to processing.

Linear Shrinkage During Processing.—The specimen used to determine dimensional change was a rectangular block with parallel ends approximately one fourth inch square in cross-section and 1¼ inches long. These specimens were smaller than those originally used by Sweeney[3, 4] for measuring linear shrinkage of denture base resins. Smaller specimens were used because it was desired to approach more nearly the practical dimensions of restorations to be made with this material. All samples were processed by packing the resin into metal molds of the foregoing dimensions, which had been previously invested in an ordinary denture flask. The proportions of powder and liquid used were those recommended by the manufacturer. The resin was packed to an excess in the mold at a stiff consistency, after which the flask was partially closed. It was then immersed in boiling water for one minute, removed and completely closed with no trial pack. The flask was then placed in boiling water and left there for the remainder of the processing interval, after which it was chilled in cold water for thirty minutes. The specimens were removed from the mold, and measurements were made by use of a micrometer calliper. The specimens showed no porosity on visual inspection.

Table 3.—Linear Shrinkage During Processing in Boiling Water

	Shrinkage		
	Processing Time 30	Processing Time 60	Processing Time 90
Name	Minutes	Minutes	Minutes
Acrynamel	—	0.35	—
Crystolex	—	0.26	—
Enameltone	0.23	0.36	0.35

The results of these tests are shown in Table 3, representing the average measurement of from six to fifteen samples for each value listed. From this table, it can be seen that enameltone and acrynamel have essentially the same shrinkage value of 0.35 per cent after being processed for sixty minutes. Crystolex shows approximately 0.1 per cent less shrinkage, which is possibly due to the stiff consistency of the material developed soon after the mixing of the powder and liquid. This behavior of crystolex is thought to allow an increased pressure to develop in the mold during complete closure of the flask.

If an accuracy of ±0.05 per cent is assumed for these tests, the difference between the shrinkage of crystolex and that of the other resins becomes insignificant. However, the measurements for all specimens of crystolex gave lower shrinkage values than did the other products tested.

Table 4.—Linear Shrinkage After One Month in Air at Room Temperature

	Shrinkage* (Per Cent)		
	Processing Time 30	Processing Time 60	Processing Time 90
Name	Minutes	Minutes	Minutes
Acrynamel	—	0.48	—
Crystolex	—	0.42	—
Enameltone	0.49	0.49	0.49

*These values include original processing shrinkage given in Table 3 combined with air shrinkage on standing.

These results are of interest since enameltone is the only product tested that employs styrene as the liquid. The results in this case are the same as those for acrynamel, which makes use of methyl methacrylate liquid.

It may be seen also from Table 3 that there is no difference in the amount of shrinkage in enameltone when processed for sixty or ninety minutes. When it was processed for only thirty minutes, how-

ever, there occurred approximately one-third less shrinkage.

For restorations demanding precision casting, it is interesting to observe that the recognized casting shrinkage of gold alloys is 1.25 per cent as compared to the foregoing values for resins. Gold alloy casting investments, however, have been developed to the point that, with proper manipulation, it is possible to compensate for this shrinkage. Whether there is actual compensation in the average practice is not known. If there is not, then restorations which fit satisfactorily should be as easily possible with the resins as with gold alloys, since the percentage of shrinkage in the resins during processing is small.

Linear Shrinkage Subsequent to Processing.—In Table 4 are given values for the combined processing and air shrinkage of specimens which have remained in air at room temperature for thirty days. These results indicate that there is a continuation of shrinkage in air after the materials have been processed for periods of from thirty to ninety minutes in boiling water; which indicates, first, that the final linear shrinkage obtained is independent of the processing time, and, second, that perhaps no processing period of less than ninety minutes in boiling water will result in complete polymerization.

The significance of shrinkage subsequent to processing is probably greatest in operative procedures, where cementation of an inlay may be affected. It may be seen by comparison of values for shrinkage during and subsequent to processing (Tables 3 and 4) that while the initial shrinkage is very satisfactory for the thirty minute processing period, the total shrinkage after thirty days is essentially the same as that for the sixty or ninety minute periods. It may be assumed, therefore, from these comparisons, that an inlay processed for thirty minutes might undergo as much as 50 per cent of its total shrinkage after being processed, if permitted to become dry for extended periods. With a processing interval of from sixty to ninety minutes, the shrinkage subsequent to processing amounts to only 25 per cent of the total. From these results, it is apparent therefore that a sixty or ninety minute processing period is most desirable. This applies equally to bridge pontics, as well as to artificial teeth for partial and complete dentures, where the danger lies in loss of a balanced functional occlusion through subsequent shrinkage.

TABLE 5.—TOTAL LINEAR CHANGE DURING PROCESSING AND AFTER 120 DAYS IN WATER AT 25° C.

Name	Processing Time	Linear Change During Processing Per Cent	Net Change After 120 Days in Water Per Cent	Increase Percentage in Water
Crystolex	60 minutes	−0.26	−0.20	+ 0.06
Enameltone	60 minutes	−0.39	−0.37	+ 0.02

In Table 5 are shown results of net dimensional change after samples of crystolex and enameltone were left in water at room temperature for 120 days. It can be seen that, in each case, the samples showed essentially no change in linear dimension. A slight expansion was observed, but the practical significance of this increase is negligible. In comparison with data in Table 4, however, it is important to observe that the linear dimensions of resin restorations are more nearly maintained when they are kept moist than when allowed to become dry. Practically, this would indicate that care should be exercised to avoid prolonged

exposure of resinous structures to air. All removable partial and complete dentures should be stored in water when not in the mouth.

Likewise, fixed structures should not be inadvertently exposed to air for extended periods of time.

Some investigators have felt that the measurement of linear dimensional change is not entirely satisfactory as a method for evaluating the dimensional stability of a resinous material.[5, 6] They believe that a measurement of the volumetric change during processing more nearly represents the true change in dimensions. According to Moore,[6] the volumetric shrinkage of the methyl methacrylate-styrene combination is only

TABLE 6.—VOLUMETRIC SHRINKAGE DURING SIXTY MINUTE PROCESSING IN BOILING WATER*

Name	Shrinkage Per Cent
Crystolex	7.96
Lucitone	7.67
Vernonite	7.88
Methyl Methacrylate—Styrene	2.79

*Moore, T. E.: Private communication.

2.79 per cent, while that of three denture base resins of methyl methacrylate powder and liquid is 7.67-7.96 per cent, as is shown in Table 6. These values are in general agreement with those indicated by Taylor.[5]

The correlation of these data with those of linear shrinkage is difficult. It seems probable that the variation in shrinkage of the two types of materials as measured by the volumetric method is due primarily to the different liquids used.

A possible reason that the difference is not shown by linear measurements is the fact that the resins may adhere to the walls of the mold during processing, or sufficient excess is available to replace the bulk, as was suggested by Taylor. Future studies are indicated to correlate the two methods of measurement.

HARDNESS

Brinell Hardness Number.—Values for the Brinell hardness number were obtained by the use of the standard baby Brinell instrument. This test is a measure of the resistance of the material to indentation. A small steel ball, one-sixteenth inch in diameter, under a constant weight of 12.6 kg., is made to penetrate the surface of the resin. The diameter of the indentation produced determines the Brinell hardness number; the larger the indentation, the softer the material, and

TABLE 7.—BRINELL HARDNESS NUMBER AFTER PROCESSING IN BOILING WATER

Name	Brinell Hardness Number* Processing Time 30 Minutes	Processing Time 60 Minutes	Processing Time 90 Minutes
Acralain	—	26.8	—
Crystolex	—	22.1	—
Enameltone	21.2	26.8	31.7
Vitain	27.1	29.0	—
24-carat gold, cast		29.0	
22-carat dark alloy, cast		54.0	
Amalgam		80–100	

*Resin values are average for several tests. For practical purposes the nearest whole number should be used.

accordingly the smaller the Brinell hardness number. A small Brinell number indicates, therefore, a soft material by comparison, while a large number indicates a hard material.

Results of tests of several products when processed for different lengths of time are shown in Table 7. Included in this table for comparative purposes are also the Brinell numbers for 24-carat gold, 22-carat alloy and amalgam.

It can be seen from this table that acralain, enameltone and vitain are of the same relative hardness when processed for sixty minutes in boiling water. Both vitain and enameltone show an in-

crease in Brinell hardness as the processing interval is lengthened from thirty minutes.

From Table 7, it can be seen further that the Brinell hardness number of these products compares well with the hardness number of 24-carat gold, but they are considerably softer than 22-carat dark alloy. From the standpoint of Brinell hardness alone, this would lead one to conclude that the resins should serve satisfactorily in protected areas, or in any position where 24-carat gold castings can be used. In structures subjected to moderate or severe occlusal stress, one would not expect the resins to behave in an acceptable manner.

Samples of enameltone, when processed for thirty, sixty and ninety minutes (Table 8), showed a continued increase in hardness when allowed to stand in either air or water for one week. There are at least two possible explanations for this increase. The first is that the materials may not be fully processed, and polymerization therefore continues in either air or water at room temperature. This is further borne out by the continued linear shrinkage which takes place in air. (Table 4.) A second explanation is offered by resin engineers to the effect that a surface "skin" begins to form on all resins immediately after processing. It is asserted that the method or length of processing time has little influence on this phenomenon. This is shown by the use of polarized light on uniformly shaped samples. Approximately twenty-four hours after processing, these samples begin to develop stress areas near their exposed surfaces. This may bear some relation to the increased hardness shown above and might well receive additional consideration.

Table 8.—Brinell Hardness Subsequent to Processing

Name	Processing Time	Brinell Hardness Number* After Processing	1 Week in Water, 25°C.	1 Week in Air, 25°C.
Enameltone	30 minutes	21.2	25.7	26.5
Enameltone	60 minutes	26.8	28.7	31.7
Enameltone	90 minutes	31.7	34.6	35.4

*These values represent the average of several tests. For practical purposes the nearest whole number may be used.

BIERBAUM SCRATCH (MICROCHARACTER) RESISTANCE

The opinion has often been advanced that the synthetic resins do not abrade or wear away so readily as their Brinell hardness value would indicate. This has often been found true from clinical experience and it led to an effort to evaluate the hardness of the resins and gold alloys upon a different basis. For this purpose, the Bierbaum scratch resistance test was used. This test consists of drawing the corner of a cubical shaped diamond, weighted with 9 gm., over the polished surface of the resin. A scratch is thus developed the width of which can be readily measured by the use of a micrometer microscope. A comparatively wide scratch indicates a soft material, while a narrow scratch represents one that is hard.

The scratch number of the various products given in Table 9 represents the reciprocal of the square of the width of the cut in microns multiplied by 10 raised to the fourth power. The larger the scratch number, therefore, the greater the resistance to scratching. Both the crystolex and enameltone samples remained overnight in water at room temperature before being tested. It is seen

from these data that the resins are comparable to 22-carat dark alloy in their resistance to scratching, even though the alloy is harder in terms of Brinell hardness number. It may be that this is the explanation of the fact that the resins do not appear to wear or be abraded to any appreciable degree after being subjected to occlusal stresses over a period of months. The resins may actually resist abrasion to as great a degree as do the common soft dental golds.

It is also seen from Table 9 that methyl methacrylate resins are more resistant to scratching than are the methyl

TABLE 9.—SCRATCH RESISTANCE

Material	Scratch Width Microns	Scratch Resistance Number
24-carat gold	14.9	44
Acrylate*	14.2	49
Enameltone	12.6	61
22-carat gold alloy (dark)	11.7	71
Crystolex	11.5	73
Dentin†	8.25	145
Amalgam†	8.10	150
Silicate Cement‡	—	275–350
Inside Enamel†	4.30	560
Outside Enamel†	2.40	1750

*Kline, G. M., and Axilrod, B.M.: Indus. & Eng. Chem., 28:1170, 1936.

†Hodge, H. C., and McKay, Harold: J.A.D.A., 20:227, 1933.

‡Ray, K. W.: J.A.D.A., 21:237,1934.

methacrylate-styrene resins. Kline and Axilrod[7] found the resins of the methyl methacrylate group to have the highest scratch resistance of all synthetic resins tested by them. The styrene resins were next highest in scratch resistance. Thus, the resins being used in dentistry for restorative purposes are the best two types available, with respect to this particular property.

WATER SORPTION

Another significant property the practical importance of which is much discussed is water sorption. This property represents the water taken into the material as well as that held on the surface after it has been wiped with a dry cloth. It is determined by first obtaining the weight of the sample that has been dried immediately after processing, and again obtaining the weight after the sample has been immersed in water for a definite period and then wiped dry with a cloth. The increase in weight represents the amount of water taken up by the resin.

For this purpose, a specimen in the form of a disk, three-fourths inch in diameter and one-fourth inch thick, was used. This specimen was chosen because it represents a mass of material with a surface area comparable to that of some of the structures that are formed from tooth restorative resins.

TABLE 10.—WATER SORPTION (PERCENTAGE) AFTER SEVEN DAYS*

Name	Percentage Change in Weight (Increase) Processing Time 30 Minutes	Processing Time 60 Minutes	Processing Time 90 Minutes
Acralain	—	0.51	—
Acrynamel	—	0.59	—
Crystolex	—	0.59	—
Crystolex powder with Enameltone liquid	—	0.41	—
Enameltone	0.42	0.45	0.46
Vitain	0.53	0.53	0.61

*In water at 25° C.

The processed sample was removed from the flask and polished, then allowed to remain in air at 50° C. for twenty-four hours. (This is the method used in the original proposed American Dental Association specification No. 12 which was in effect at the time this study was undertaken. It has since been observed that a temperature of 50° C. in air continued for twenty-four hours may not be sufficient to develop a constant weight. Hence, data in Tables 10 and 11 may vary slightly from the true value. They

are believed to be sufficiently accurate to indicate general, practical comparisons.) They were then weighed, and immediately immersed in distilled water for seven days at room temperature (25±2° C.). At the end of this interval, they were removed from the water and wiped dry with a clean cloth before being weighed a second time. From the difference obtained, the percentage of water sorption was calculated.

It should be kept in mind that these values represent a seven-day, rather than a twenty-four-hour, immersion period, and for this reason they are somewhat greater than those reported by other investigators who have used a shorter time. It was considered that the longer period gives a better indication of the water sorption obtained in the mouth.

Table 11.—Material Dissolved or Leached Out During Seven Days in Distilled Water (25°C.)

	Percentage by Weight		
Name	Processing Time 30 Minutes	Processing Time 60 Minutes	Processing Time 90 Minutes
Acralain	—	0.12	—
Acrynamel	—	0.10	—
Crystolex	—	0.09	—
Enameltone	0.08	0.07	0.12
Vitain	—	0.04	0.12

Results from these tests are included in Table 10. From these values, it may be seen that there is little difference in water sorption of enameltone or of vitain when the samples have been processed for thirty, sixty or ninety minutes. When processed for sixty minutes, it is seen from the table that acrynamel and crystolex have the same percentage of water sorption, while enameltone has about 25 per cent less sorption. Acralain and vitain have values intermediate between those of acrynamel and enameltone. This difference is apparently due to the fact that styrene liquid (monomer) is used in enameltone, while methylmethacrylate liquid is used in the other products. This difference is made more evident from the results of using enameltone (styrene) liquid with crystolex powder (polymer). This combination lowered the water sorption from 0.59 to 0.41 per cent. The latter value is similar to that obtained for enameltone powder and liquid when processed for sixty minutes.

In view of these data, which indicate that the total water sorption in a seven-day period is about 0.5 per cent, the practical significance of this property becomes doubtful. It may become significant when it is related to other properties, or when it becomes excessive. However, when the water sorption is within the limits shown in Table 10, it seems that possibly it is of little importance. This view is supported by a statement from the Plastics Department of the DuPont Company[8]:

> The importance of water sorption of a material depends on its effect on other physical properties of the material and upon the application for which the material is intended. . . . For plastics, as a general rule, it is harmful. Absorption of water lowers their tensile strength, flexural strength, resistance to high temperatures and electrical resistivity. On the other hand, it does increase their toughness and pliability, as indicated by impact test results.

Table 12.—Impact Resistance, Izod Method*

	Inch-Pounds Resistance		
Name	Processing Time 30 Minutes	Processing Time 60 Minutes	Processing Time 90 Minutes
Acralain	—	1.14	—
Crystolex	—	2.15	—
Enameltone	1.94	2.19	1.95
Glazed fused porcelain (Range of ten samples)		2.00-3.50	

*Schultz, L. C., and Weller, A.: Unpublished data.

WATER SOLUBILITY

Closely associated with the property of water sorption is the property of water solubility. The samples used to determine this property were the ones used for water sorption. After the water sorption measurements were completed at the end of seven days, the samples were placed in a warm air oven at 50° C. and left for twenty-four hours, after which they were again weighed. The difference between this final weight and the original weight represented the amount of water-soluble ingredients which were leached out during the seven days that the sample was immersed in water.

The results of the measurements are shown in Table 11. From this table, it may be seen that the results are similar for the different products tested and for the various processing periods employed. In each case, the percentage by weight of solubility was relatively small, with an average value of approximately 0.1 per cent. The accuracy of these values is considered to be in the order of 0.05 per cent. In comparison, the water solubility of silicate cements used as esthetic anterior filling materials is in the order of 1.0 per cent, or more, after seven days in water. Thus, it is seen that these resins have a solubility only about one-tenth that of silicate cements. On the basis of solubility alone, it appears that restorations made with these resins would be more satisfactory than those made with silicates. In fact, when the solubility of the resins remains as low as that given in Table 11, it may be regarded as insignificant from the practical standpoint.

IMPACT

It is generally believed from clinical experience that restorations made from synthetic resins are less likely to fracture from oral stresses than are similar ones made from fused porcelain. This resistance to fracture has been considered by some to be due to the greater impact resistance of the resins. Since unpublished data were available in our laboratory for impact strength of fused porcelain that had been baked according to general practice, it was decided to test the resins under comparable conditions.

For this test, cylindrical samples $1\frac{1}{4}$ inches long and one-fourth inch in diameter were processed in a split metal mold embedded in a denture flask. As indicated in Table 12, the samples were processed for periods of from thirty to ninety minutes in boiling water. These values represent an average of three to five specimens. Immediately after processing, the samples were tested in an Olsen 10 inch-pound Izod impact machine. The average variation was in the order of 0.5 inch pounds. In this type of test, the sample is rigidly clamped in an upright position and struck with a

TABLE 13.—COLD FLOW OR DISTORTION UNDER STRESS—AFTER SEVEN DAYS*

Name	Processing Time	Flow or Distortion (Per Cent)	
		Total Distortion After Seven Days of Applied Stress	Permanent Distortion Stress Removed
Acralain	60 minutes	3.1	2.4
Enameltone	30 minutes	8.6	8.0
Enameltone	60 minutes	2.2	1.6
Enameltone	90 minutes	2.4	1.8
Amalgam.†		7.3	
Gold, 24-carat (annealed)†		1.7	

*3,550 pounds per square inch stress

†Ward, M. L.: American Textbook of Operative Dentistry, 1940, p. 504.

pendulum having sufficient force to fracture the specimen. The amount of energy consumed in fracturing the sample is recorded in inch-pounds. The test conditions were the same for porcelain and the resins.

From Table 12, it is interesting to observe that the impact values for resin and porcelain indicate that there is little difference between the two materials when tested under identical test conditions. Inasmuch as this does not agree with clinical observations, one is led to believe that results obtained from testing rigidly supported impact samples do not indicate the true resistance to fracture from shock, and that the difference in elasticity of the two materials should be considered as an influencing factor. In no case does it seem advisable to state that the impact resistance, as measured and described, of resins is greater than that of ceramic materials. It has been observed that resins may be distorted appreciably without breakage, as in a transverse test, while porcelain will readily fracture if subjected to such distortion. From these data and comparisons, one can conclude that results from comparable transverse tests of the two materials might be more significant than impact values for comparison of resins and fused porcelain as restorative materials.

COLD FLOW

It has already been pointed out that the hardness of these resins is approximately the same as that of pure gold. This observation, combined with the fact that they are plastic materials like waxes and amalgams, which are subject to distortion and flow, leads one to question whether the synthetic resins exhibit similar plastic properties. In an attempt to determine the extent of this characteristic property of plastics, samples were subjected to the flow test that has been described in the American Dental Association specification No. 1 for amalgam alloy. This test fundamentally consists of applying statically a 3,550 pound per square inch stress to a cylindrical specimen 8 mm. long and 4 mm. in diameter. The amount of shortening that occurs in the sample under this stress is calculated in percentage of total length, and represents the flow.

The resin specimen was machined to dimension and the load applied within two hours after the processing was complete.

In Table 13 are given the results from tests on two resins processed for varying lengths of time, together with the flow value for 24-carat gold and a certified amalgam alloy, which have been included for comparative purposes. These values were obtained after a seven-day interval. It may be seen from this table that the flow for the two resins is from 2.2 to 3.1 per cent, as compared to 7.3 per cent for amalgam, and only 1.7 per cent for the gold. It is seen that the thirty-minute processing period gives a flow value which is in the same order as that of amalgam, this again indicating that a longer processing time is desirable. From a comparison of columns A and B of Table 13, it can be observed that the percentage of permanent distortion is about 0.6 per cent less than the total distortion. Thus, there is an elastic recovery of dimensions which occurs when the stress is removed.

These observations would indicate that restorations made from resins are not subject to excessive flow resulting from stresses occurring in the mouth, and are exceptionally well able to resist fracture by these stresses, owing to their plastic flow and elastic recovery of dimensions. Possibly for these reasons, the resin restorations resist occlusal force as well as those of materials of greater hardness. Clinical observations tend to bear out this conclusion.

SUMMARY

One of the original purposes of this study was to determine which of the two

types of resins now available is most suited to restorative work. From the assembled data, it appears that the methyl methacrylate polymer and styrene monomer combine to form a slightly more satisfactory product. Nevertheless, the difference is so slight that an imperfect technic in the handling of a resin of this type might render it inferior to a well-handled methyl methacrylate resin. The advantage is available only to the operator who is skilled enough to produce a processed resin of the highest quality. There is certainly no evidence that the methyl methacrylate products differ appreciably among themselves in their physical properties. As might be expected from their composition, the properties of tooth restorative resins have been found to be similar to those of denture base resins. This was shown by a comparison of values obtained on one denture base resin with values from products designed for tooth restorative purposes.

Another purpose of this study was the determination of the most desirable length of time for processing the synthetic resins in boiling water. It appears definite that a sixty-minute period is satisfactory, while a ninety-minute period is somewhat better as regards hardness. Apparently, the materials are polymerized to a sufficient degree at the conclusion of sixty or ninety minutes, so that they can be considered completely processed. Additional studies can well be undertaken to determine the time and temperature that will develop the most practical and satisfactory processing procedure.

In addition to the properties that have been studied, a large number of problems remain, both in the laboratory and in clinical practice. To be specific, the cementation of synthetic resin inlays is the source of much concern at present. These inlays frequently break their cement seal and become dislodged. This may be due to the large coefficient of thermal expansion peculiar to the resins, to the fact that cement does not adequately wet the surface of such inlays or to the elasticity of the materials. There are a number of other possible causes, one of which is improper cavity design.

The question of injection molding as opposed to compression molding should be investigated in the near future. In the past year, certain laboratories and manufacturers have made many claims for injection molding to the dental profession. Studies of this problem by competent investigators will do much to remedy the confusion now present in the minds of many dentists concerning it.

This study, in conjunction with the limited clinical experience that has thus far been gained in the use of the resins, leads to the conclusion that there are perhaps several satisfactory applications of these materials. Additional studies of physical and mechanical properties, and further clinical experience will undoubtedly definitely establish the limits of these applications. The feeling of many leaders in the profession seems to be that the acrylic resins probably can give satisfactory service in several types of restorations. If, however, the restoration is improperly processed, or placed in contraindicated positions, failure will undoubtedly result.

CONCLUSIONS

1. The physical properties of two types of tooth restorative resins (acrylic and acrylic-styrene) were examined and compared for the properties of linear change during and subsequent to processing, volumetric shrinkage, Brinell and scratch hardness, water sorption and solubility, impact resistance and cold flow.

2. In boiling water, a sixty to ninety minute processing interval appears most satisfactory.

3. Little measurable difference exists between the acrylic and acrylic-styrene tooth restorative resins. However, acrylic-

styrene appears to show a slight superiority in physical properties.

4. The shelf-life of the methylmethacrylate powder and liquid is indefinite. If not properly stored, the styrene liquid will solidify on standing.

5. From the data presented, it appears that the resins have satisfactory properties for tooth restorative purposes when they are properly processed and used with discriminating judgment.

6. The extent to which these resins can be safely used is to be determined from clinical experience combined with data on physical properties.

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EFFECT OF OPERATIVE PROCEDURES ON NON-CARIOUS TEETH OF YOUNG PERSONS

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THE literature relating to the preparation of vital teeth for crowns and fixed bridge retainers is replete with statements emphasizing the necessity for pulp preservation. That all contributors to the field of fixed denture prosthesis are not only aware of the danger, but also constantly guarding against pulp injury verifies the opinion that serious consequences may follow operative interference. The preparations for full or partial veneer crowns and extensive inlays are often made on non-carious teeth involving large areas of sound tooth tissue. The extensive sacrifice of enamel and dentin is justified in order to remedy the numerous ill-effects of absence of teeth.[1] However, the method of replacing missing teeth by fixed partial dentures frequently involves extensive destruction of sound dentin and enamel, and occasionally results in loss of vitality of abutment teeth, complicating an already undesirable situation.

It is generally known that the pulps of teeth diminish in size with age. This condition has been observed by most operators and it is usually verified by an x-ray examination. One need expose a pulp only once to be conscious of this fact for life. An exposed pulp may be observed by the operator, whereas other ill-effects on the pulp generally manifest themselves clinically only at a subsequent period, if at all. The incidence of pulp

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involvement may be reduced by a better understanding of the biology of the calcified dental tissues.

Most operative technics for retainers have been established by the trial and error method, the primary consideration being the mechanical features of the retainer. The responsibility for this concept must be shared by the entire profession because many biologists have accepted the erroneous idea that calcified tissues are dead, primarily because they contain no cells and cannot regenerate to supply lost parts. Even the term "tissue" may be a misnomer. Strictly defined, a tissue consists of an aggregation

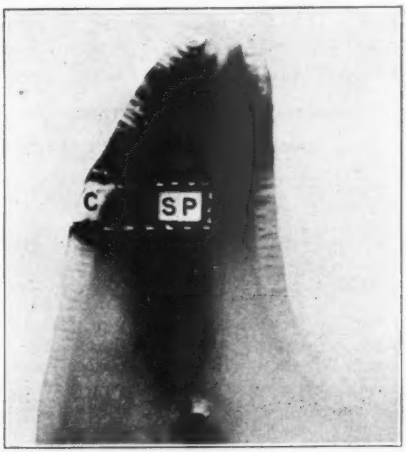

Fig. 1.—Tooth of a dog stained in vivo with potassium permanganate for seven days. Stain placed in the stain pocket (S.P.) diffused through the tubules to the pulp and into the enamel. C, cement.

of cells and intercellular substance having a common function. In this sense, enamel and dentin can scarcely be designated as tissues. However, through common usage over a period of many years, the term "calcified tissue" has been established, and it will be used in this report.

Acceptance of calcified tissues as dead gave impetus to the development of many new technics for the preparation of retainers. Therefore, indiscriminate destruction of sound tooth tissue followed. With all the new methods, the statement "care must be exercised not to injure the pulp" was added because, despite the general acceptance of the "dead" tissue idea, severe injury to the pulp often ensued. There can be no doubt that the most important consideration in the preparation of abutment teeth is the continued vitality of the tooth.

G. V. Black[2] is considered a pioneer in establishing operative technics based on histologic findings. Bodecker has rendered a similar service to the profession in establishing operative principles based on age changes of the calcified dental tissues. He says[3]:

The linking of our clinical work with the

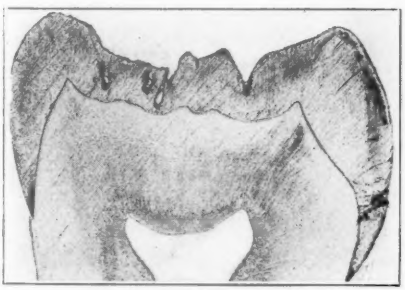

Fig. 2.—Typical appearance of ground section of young dentin in recently erupted third molar. The dentin was clear and translucent. Pulp irritation is more likely to follow operative interference. (Figures 2, 3, 6 and 7 courtesy of C. F. Bodecker.)

biologic reactions of the teeth is a fascinating and engrossing subject, knowledge of which will do much to improve our operative procedures. With the knowledge gained from such a correlation, we shall be able to interpret symptoms more exactly. Also, we shall be able to vary our technic to fit the individual case.

The practitioner who operates on the calcified tissues must understand the biologic processes in order to render the best service to his patient. Most important is the realization that enamel and dentin possess a low degree of vitality.

As the tooth ages, the vitality is diminished. The correlation of this knowledge with operative technic will prove advantageous to the careful operator and to the patient.

THE "VITALITY" OF THE CALCIFIED DENTAL TISSUES

Bodecker,[4] Beust[5] and Churchill[6] agree in principle that physical and chemical changes in the intercellular substance are evidence that a low degree of vitality exists. Prinz,[7] Fish,[8] Bertram[9] and, more recently, Bodecker and I[10] have demonstrated that dyes are transported through the calcified tissues, but it remained for the latter authors to establish the mechanism on the basis of Bodecker's

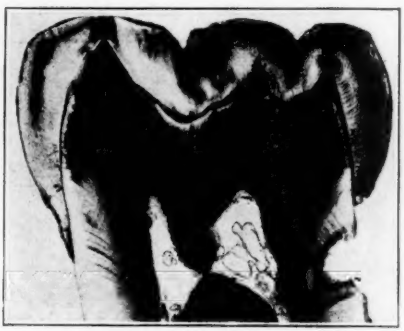

Fig. 3.—Typical appearance of metamorphosed dentin in ground section of matured tooth. The dentin was opaque. Pulp irritation is less likely to follow operative interference because of the impermeability of dentin.

earlier hypothesis.[11] It is interesting to note that his hypothesis was founded originally on observations of histologic sections. The experimental vital staining of teeth established the presence and diffusion of a fluid, dental lymph, which originates in the pulp and permeates the enamel and dentin. The fact that it diffuses in two directions suggests the possibility that it is responsible for the senescent changes evident in these tissues.

The diffusion of dental lymph can be observed in Figure 1. Dry silver nitrate was placed in a stain pocket prepared in a young dog's tooth *in vivo*. The tooth was extracted seven days later and ground in oil. It may be observed that the dye diffused centripetally and centrifugally. Additional knowledge of the rôle of dental lymph has been reported in the literature.[12, 13, 14, 15] It has been observed that dyes inserted in the vital pulps of young human beings and animals permeated the entire body of the dentin and the organic matrix of the enamel. Dyes placed on the periphery of the dentin were transported by the dental lymph to the pulp. It has been impossible, however, to introduce dyes into the calcified dental tissues through normal enamel from the surface of the tooth. This was made possible in only those areas where decalcification had occurred, such as incipient enamel caries.

PROTECTIVE METAMORPHOSIS

The most important finding to the

Fig. 4.—Early stage of dentin metamorphosis, showing decomposition of dental lymph, forming gas bubbles. L, dental lymph. G, gas bubble.

practitioner is that the diffusion of dental lymph is greatest in young teeth. With increasing age, the dentin undergoes a change, which has been termed protective metamorphosis by Bodecker.[16] Up to the present, it may be observed only microscopically in ground sections. Figure 2 shows a ground section of a recently erupted third molar. The dentin is clear and translucent. The dentinal tubules in this tooth are filled with lymph. In this stage, dentin is highly permeable and possesses a higher degree of vitality than metamorphosed dentin. Its exposure to the fluids of the mouth, germicides and other chemical irritants permits their passage into the pulp. The

danger of injury to the pulp by chemical irritation is markedly increased in young teeth.

The dentin of older teeth appears altogether different in a ground section. Figure 3 shows a section of a molar of an older person in which protective metamorphosis of the crown has occurred. The dentin is opaque and the tubules appear coarser. Because dentin in this stage is highly impermeable, irritants do not reach the pulp. It is also far less sensitive to operative interference. The changes in dental lymph which result in protective metamorphosis may be observed microscopically under higher magnification. This metamorphosis has been described as a degenerative process in which the dental lymph breaks down, forming first a gas and, later, probably lipids and calcific plugs which seal the

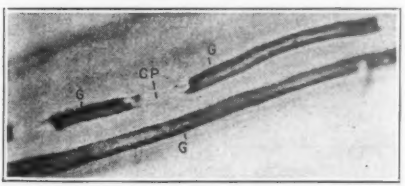

Fig. 5.—Further decomposition of dental lymph. The rounded ends of the gas bubbles shown in Figure 4 have become irregular, this indicating a further stage in decomposition. C, gas remnant. CP, calcific plug.

dentinal tubules. Figure 4 is a photomicrograph of an early stage of metamorphosis. The dental lymph has partly decomposed within the dentinal tubule, forming a gas which has the appearance of an air bubble similar to that seen in a carpenter's level. The lymph occupies the tubule between the gas bubbles. At a later stage (Fig. 5), there is further drying of the lymph, producing what appears microscopically as calcific plugs. The major part of the tubule is filled with gas produced by decomposition of the lymph.

A similar change in young dentin occurs from exposure as found under areas of caries, attrition and erosion and in cavity preparation. Under these circumstances, a layer of secondary dentin forms, bounded by the affected tubules, and the primary dentin in this area undergoes protective metamorphosis. This renders the dentin less permeable. It is not known whether protective metamorphosis resulting from exposure of dentin precedes the formation of secondary dentin. Both are found in path-

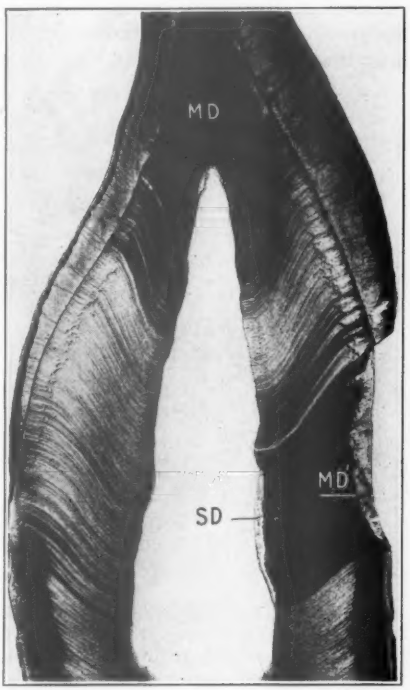

Fig. 6.—Central incisor. Abrasion on the labial surface produced secondary dentin (SD). The similarity between the metamorphosed dentin (MD) in the crown and in the abraded area (MD') is evident.

ologic cases. However, the normal metamorphosis of the primary dentin as observed in older teeth shows no irregularly formed secondary dentin. Up to this point, it has not been possible to observe any difference between protective metamorphosis as observed in older teeth

as a biologic process and that resulting from loss of enamel in young dentin. Figure 6 is a photomicrograph of a central incisor in which metamorphosis of the crown dentin had begun. On the cervical areas of the labial surface, an abrasion can be observed which resulted in metamorphosis of the dentin and formation of secondary dentin. The metamorphosis of the crown dentin appears similar to that produced by the abrasion.

The significance of protective metamorphosis cannot be underestimated in preparing teeth for retainers. The diffusion of dental lymph in the metamorphosed area has been arrested. The tissue becomes harder and more brittle. Experimentally, it has been impossible to introduce stains into these areas to demonstrate their impermeability.[10] Likewise, it is impossible for irritants to pass to the pulp from the dentin. It is impermeable to the fluids of the mouth and other irritants, such as sterilizing solutions, and free acid of dental cements and, to some extent, is less liable to injury of the pulp by the generation of heat. Thomas,[17] in a report of the penetration of phenol in tooth structure, found that metamorphosed dentin was impermeable to phenol; whereas, in young dentin, it penetrated to the pulp.

Similarly, enamel undergoes a change with age. This change is manifested by an increased hardness,[17, 18] termed maturation.[5] Histologically, the enamel is more translucent than the recently erupted or immature tissue. As far as our present knowledge goes, removal of the surface of the enamel, without exposure of the dentin, will have no deleterious effect on the pulp.

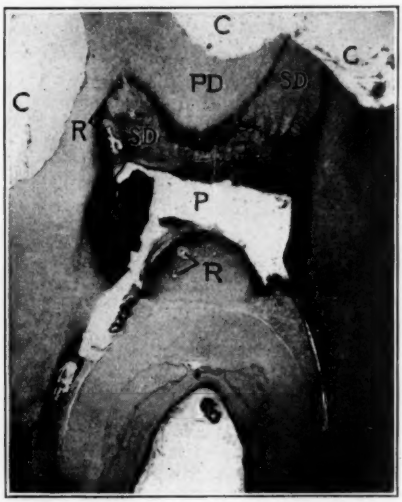

Fig. 7.—Upper first molar filled at age of 8 by extensive metallic restoration. Secondary dentin (SD) formation followed. The tooth was refilled several times until necrosis of the pulp occurred, about forty years later. R, resorbed areas of primary and secondary dentin. PD, primary dentin. C, cavities previously filled.

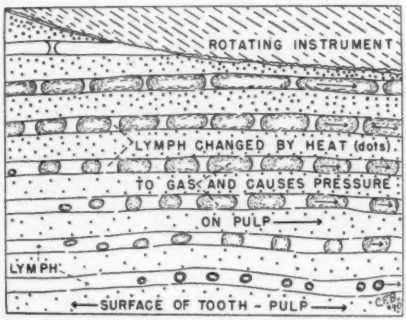

Fig. 8.—Diagram showing effect of frictional heat upon young dentin. (Bodecker.)

REACTION OF THE PULP TO CAVITY PREPARATION

The reaction of the pulp to cavity preparation and filling materials has engrossed the profession for many years. Recent observations in these fields were reported by Fish,[20] Manly,[21] Van Huysen and Gurley[22, 23, 24] and others. Cavities were prepared in sound teeth, some of which were filled and others exposed to the fluids of the mouth. After varying periods, they were extracted and exam-

ined microscopically. There can be no doubt that the operative interference was judicious. Nevertheless, it must be borne in mind that experimental procedures of this type are subject to many variables. In the first place, no consideration was given to the age of the tooth. Because all specimens were decalcified, it was impossible to determine the degree of dentin metamorphosis. Other variables are the speed of the operative procedure, the heat generated, the pressure, the use of germicides and other conditions peculiar to each operator. It is interesting to note, however, that, in almost all the cases, the results were similar. Some operators attributed the results to the surgical trauma; others to the depth of the cavity, and others to the filling material. These experiments simulate quite closely in technic the excavation of abutment teeth, so far as they were carried out on sound teeth. Cavity preparation in areas where caries, attrition, abrasion or erosion exists will undoubtedly have a different result inasmuch as metamorphosis of the dentin has occurred to some extent even in young teeth.

In these experimental studies, Fish[20] prepared cavities in the teeth of dogs and monkeys, using phenol for sterilization and filling the teeth with copper oxyphosphate cement. He observed that "the reaction to peripheral injury of dentin is very similar to the ordinary inflammatory reaction which follows a superficial wound to the soft tissues." In all cases, he found round-cell infiltration in the affected area and destruction of the odontoblasts. In 50 per cent of the cases, there was hemorrhage in the pulp. In extreme instances, a granuloma formed in the affected area of the pulp, and occasionally necrosis followed. Fish demonstrated that the formation of secondary dentin results from peripheral injury, and

Fig. 9.—Section of tooth that had had full veneer crown. All the enamel had been removed to comply with the requirements for preparation of the cavity. Metamorphosis of dentin was evident.

Fig. 10.—Section of tooth that had had full veneer crown. The preparation was unsatisfactory. There is enamel in situ. An early stage of metamorphosis of dentin is evident.

if the injury to the pulp is severe, the secondary dentin formation may be delayed for several months.

An interesting study by Manly[21] reported that indiscriminate cavity preparation may cause hemorrhage and necrosis of the pulp. He used the teeth of young dogs in his experiments. Their teeth are even more permeable than young human teeth. The operative procedures were performed with a slow motion handpiece, reducing the number of revolutions of the bur 90 per cent. In this way, trauma and heat were minimized. Manly found that insertion of zinc oxide and eugenol in the cavity immediately gave no reaction. Insertion of amalgam gave a slight reaction, and the sharpest reaction was noted with cements.

Similarly, three reports by Gurley and Van Huysen[22, 23, 24] show severe pulp changes in cavities excavated to half the thickness of the dentin in dogs' teeth. The deeper the cavity, the greater the reaction. Their findings corroborate the results of Manly. In addition to zinc oxide and eugenol, gutta-percha temporary stopping showed the least ill effect. Insertion of cements showed the greatest reaction in secondary dentin formation and pulp irritation.

In examining these findings, it is difficult to establish the cause of the violent pulp reaction. It may be due to one or all the factors involved. It is important to note the similarity of these experiments to the procedure of preparing teeth for retainers. In both cases, the cavities are cut into sound tooth structure. The dentin of lower animals possesses a higher degree of vitality than young human dentin. The cutting of young dentin is in itself a greater source of irritation to the pulp than the cutting of metamorphosed dentin. Furthermore, the depth of the cavity is proportional to the extent of the injury. This justifies the statement of Tylman[25] that one type of extracoronal retainer, partial veneer crowns, provides a maximum of retention with least danger to the pulp and minimum sacrifice of tooth structure.

In the past, the pulp has been considered a delicate organ. This concept has changed with the improved understanding of connective tissue and its function in disease. While it is impossible to measure the tolerance of any individual pulp to irritation, it may be expected that the pulp will usually recover from severe injury short of exposure and persisting infection, to which it is sometimes subjected. The recovery is generally associated with secondary dentin formation which is dependent upon the nature of the irritant. The stimulation to the pulp in caries, attrition or abrasion is mild and gradual. The processes, which are slow, affect the terminal ends of the tubules first. The affected area increases in size slowly. Secondary dentin thus produced is comparatively well formed, with regular tubules indicating a normal response of a healthy pulp. In contrast, the effect of operative interference is much more marked. Many tubules are opened at one time and are often severed at a considerable depth. Secondary dentin formed as a result of severe irritation is irregular and contains few tubules. It may also contain necrotic pulp tissue, or resorption of the dentin may occur. Figure 7 is a section of an upper first molar which was prepared for filling at the age of 8 years. The pulp reacted to the severe irritation of caries, cavity preparation and a metallic restoration, an extensive deposit of secondary dentin resulting. Additional caries and restorations resulted in further irritation until necrosis of the pulp necessitated removal of the tooth at the age of 50. Areas of resorption (R) can be seen in both the primary and the secondary dentin.

Severe injury to the pulp may retard the formation of secondary dentin. This retardation is often manifested by a prolonged sensitiveness to thermal shock. The symptoms disappear with the formation of secondary dentin or necrosis of

the pulp. Fish[21] attributes the delayed secondary dentin formation to necrosis of the affected area of the pulp. Thoma[26] attributes continued sensitivity of a tooth to heat to infection of a vital pulp, which may persist for a long period. He believes that the organisms enter the pulp through the dentinal tubules. There can be no doubt that either condition is more likely to occur in young dentin.

TEMPORARY FILLINGS

Another factor in reducing pulp irritation is the use of temporary fillings to afford the tooth protection against oral secretions, organisms, temperature shock and pressure, as recommended by Bodecker.[30] Thoma[26] presents the problem well:

> The feeling that a tooth which has been cut into by a bur or other instrument represents an open wound must be acquired. A wound in a tooth should have the care and consideration that is given a wound in any part of the body, perhaps more, because the injured dental canals represent a wound surface more easily infected than a cut in the skin. A tooth does not have the facilities for protection that the soft tissues possess. The cleansing of a wound by hemorrhage from it, and the healing process, which, in the soft tissues, includes the formation of a protective crust over the injured surface, are not present in the dentin. It is no wonder, therefore, that a pulp becomes infected if a cavity, although properly prepared, is left unprotected for days until a crown is set or an inlay cemented into place.

In reports on pulp reactions to temporary fillings, Manly[21] and Van Huysen and Gurley[22, 23, 24] state that, experimentally, zinc oxide and eugenol or gutta-percha was the least irritating. Grossman,[27] studying the physical properties of temporary fillings, found that zinc oxide and eugenol formed the most perfect seal. Bodecker[3] has long recommended, wherever possible, the use of base-plate gutta-percha and camphorated validol in hypersensitive cavities. In addition to having a sedative effect on the dentin, camphorated validol acts as a slight solvent of the gutta-percha, and thus the dentinal tubules are sealed. It is easily manipulated and can be inserted when quite cool. Upon hardening, it will, to a fair degree, resist the stress of mastication. Its advantage over zinc oxide and eugenol is that it may be removed en masse by the insertion of a hot instrument in the filling, slightly softening the mass. The use of a temporary low fusing metal covering or inlay as advocated by Tylman[28] is also recommended. It will not afford much protection against thermol shock during the period that secondary dentin forms and metamorphosis occurs.

HEAT

The generation of heat in preparing abutment teeth has received much consideration. Hartman[29] states that "most of the putrescent pulp and abscesses which follow the placing of crowns on what seemed to be perfectly normal teeth before the preparations were made may be traced to the heat generated in making these preparations."

Bodecker[30] explained the mechanism by which heat not only produces pain, but also results in injury to the pulp. The degree of diffusion of dental lymph is an important factor in his observation. In young teeth, these tubules are filled with dental lymph as previously described. Figure 8 demonstrates one mechanism by which the pulp is injured by heat. The rapidly revolving bur (R.I.), on contact with dentin, develops frictional heat. The intensity of the heat is demonstrated by the dots, and it affects not only the tubules being cut, but also the adjacent ones. The heat volatilizes the dental lymph (D.L.) in the intact tubules (I.T.), causing the expansion and transmission of the pressure to the pulp because the vaporized dental lymph cannot escape outward. Lymph expansion probably explains the local destruction of the odontoblasts. In older teeth in which

dentin has undergone protective metamorphosis, the decomposed dental lymph cannot be vaporized. The danger then is the transmission of heat through the dentin matrix to the pulp. One must not minimize the danger of heat in all teeth, but must realize the greater danger in young teeth.

DISCUSSION

These findings are contradictory to many operative procedures. With the exception of the size of the pulp chamber, no special reference has been made to the requirements for cavity preparation in young teeth. It has been recommended by Kesel and Stephan[31] and Tylman[32] that the entire preparation be made at one sitting. For the older patient, this is acceptable. The metamorphosed, impermeable dentin prevents irritation from adversely affecting the pulp. Medicaments will not penetrate, nor will the fluid and organisms of the mouth. The only danger is that arising from heat, which is diminished to a certain extent.

The procedure of preparing a young tooth for a retainer should be reconsidered. Exposure of the dentin produces a severe pulp reaction. This is further aggravated by infection or chemical irritation, owing to the permeability of the young dentin. It is important that a safe method of stimulating secondary dentin and bringing about a protective metamorphosis be found. Experimental investigations to develop technical procedures are being planned. This must be supplemented by clinical observations. G. V. Black recommended the use of zinc oxyphosphate or gutta-percha to allay sensitivity of the teeth. After a few weeks or months, preparation of the cavity may be made painlessly. Bodecker's explanation of the process[16] opens a new field in cavity preparation. Orban[24] advocated using a formalin cement to produce secondary dentin. His animal experiments were highly successful. Its use on human beings is still to be reported.

The work of Gurley and Van Huysen[22, 23, 24] and their predecessors suggests a method of approaching this problem. After extractions, a period of from one to two months is required for resorption of the alveolar border and healing of the socket. This time can be utilized to bring about premature metamorphosis by operative interference and the use of mildly irritating temporary fillings in abutment teeth. The outlines of the retainers may be prepared, the dentin being exposed at the dentino-enamel junction. This may even be done at several sittings without the use of anesthetics. The danger to the pulp will be minimal because the cavity has little depth. Each small shallow area should be protected with an irritating temporary filling. Gutta-percha and validol or zinc oxide and eugenol may not lend itself to the formation of secondary dentin where the peripheral injury is so shallow. Oxyphosphate cement should suffice at this depth. The purpose of this procedure is to mildly irritate the pulp so that it will produce secondary dentin. This irritation will establish a zone of metamorphosed dentin over it. The desirable change in the primary dentin should be completed by the time the socket is healed, making it possible to complete the preparation with the least ill effect on the pulp. Clinical observations on this procedure should be an advantageous adjunct to experimental studies.

A precaution which should be universally observed is the protection of large areas of exposed young dentin with varnish. It has been found that varnish will protect enamel from decalcification by oxyphosphate cement.[35] It is reasonable, therefore, to assume that the use of varnish will also offer the pulp protection from chemical irritation in the case of young permeable dentin. This has been recommended by many prosthodontists, not only to prevent chemical

irritation of the pulp, but also to exclude bacteria. If the use of oxyphosphate cements produced the greatest pulp reaction, cementing a retainer in a tooth before metamorphosis may have the same result.

There is no doubt that intact sound enamel affords the best protection for the dental pulp. Consequently, the question arises, "Is it necessary to remove all the enamel and expose the dentin in the preparation of abutment teeth?" There is some difference of opinion in this matter, and most discussion of the practice of removing all the enamel centers around the full porcelain veneer crowns. Tylman[36] suggests that, in preparing the lingual surface of a partial veneer crown or a complete veneer porcelain crown, it is not necessary to remove all the lingual enamel. Squires,[37] on the other hand, suggests removal of all enamel and recommends a varnish to protect the exposed dentin. The practice of preparing sound teeth should be altered to include the retention of as much enamel as possible. In discussing full veneer crowns, Ante[38] estimates the sacrifice to be one sixth of the tissue on the axial walls and one fourth on the occlusal surface. He suggests that, in vital teeth, the sacrifice is too great. There can be no doubt that, in the preparation of teeth for full veneer crowns, there is extensive sacrifice of the enamel. If this preparation is to be made on a young tooth in one sitting, the pulp reaction may be sufficiently severe to result in necrosis.

Figure 9 shows a ground section of a tooth that had been well prepared and that carried a crown for many years. All the enamel had been removed. Complete metamorphosis of the coronal dentin can be seen. This type of preparation, while embodying all the requirements for a good crown, must be considered a dangerous procedure in a young patient. By contrast, Figure 10 shows a section of a tooth which had been poorly prepared for a full crown. Almost all of the enamel is *in situ*. There is little metamorphosis of the underlying dentin. Metamorphosis of the dentin must be considered a desirable stage inasmuch as it is then less susceptible to caries. However, in stripping the enamel of the tooth, the danger of pulp necrosis overshadows the benefits of premature dentin metamorphosis. Therefore, it becomes the duty of the profession to establish new forms of fixed bridge retainers and to devise other operative procedures on sound tooth structure that will conserve the enamel. It should be possible to prepare a three-quarter veneer crown without removing the lingual enamel, particularly if the bite does not interfere.

SUMMARY AND CONCLUSIONS

Operative procedures, particularly those performed on sound tooth tissues, have a harmful effect on the pulp. In extreme cases, they may result in necrosis of the pulp. This may be attributed to the effect of operative interference on sound dentin, chemical irritation of the pulp through the dentin, improper tooth protection of exposed dentin and heat. The danger of pulp injury is greater in young teeth owing to higher permeability and increased activity of the dental lymph. Changes in operative technic are recommended to permit the natural protective mechanism to become effective before deep preparations are made. It is also recommended that a new technic be developed permitting the retention of as much enamel as possible.

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OCTOBER 1 *Editorial Department* 1942

POST-WAR DENTISTRY

IN one of his final messages as President of the American Dental Association, Dr. Oliver reminded the Association that urgent as is the need for concentrating on the war task immediately before us, it is desirable and quite as urgent to begin giving some thought to the character of the practice of dentistry after the war. And, in following this injunction, we are inevitably led to a consideration of the dominant trends of dentistry as evidenced in and influenced by the political and social upheaval in which we find the world today.

In modern times, the political evolution of every nation appears to be toward economic security, and health security is naturally embraced in any comprehensive plan of economic security. The present federal provision for health service for the unemployed is only slightly removed from the adoption of a more comprehensive service that would include all classes that are unable to avail themselves of adequate health service. Today the politico-social trend in America is definitely toward social security, particularly in its health aspects and implications.

Probably the first and most important factor in promoting social security is the provision for health that will enable the individual to pursue without hindrance his efforts toward maintaining his social position. The modern politician has cleverly capitalized on that social ambition, and the present plan of federal security no doubt will eventually include federal provision for assuring the health of the individual.

It was as far back as 1928 that the welfare workers and socially minded realized the interference of the cost of dentistry in the attainment of the health ideal, and it was then that the inquiry into the costs of medical care created the desire to investigate the costs of dental care. And, paradoxical as it may seem, those who studied and determined the cost of dental care and the reasons for the high cost of dental care received scant praise for their effort. In fact, the advocacy of some remedial system prompted by the findings brought discredit to the point of chastisement of some who were elected by the profession to do the fact finding.

The reaction of the fact-finders, however, was only an expression of the trend which today is so apparent in the health field. The present cost of medical care and the cost of dental care are so plainly out of line with the economic demands that the political elements are eagerly seeking an economic answer, and it appears that that answer will come through the control and direction of health service by governmental authority. Experiments have been and are being made to meet the demand for a more reasonable health service, through hospital insurance plans and group medical practice, with but slight success because of the unrelenting opposition from the medical profession to any method of procedure that might in any way disturb the hereditary traditions of medical practice. Now, however, the demands of the Army for adequate health service has moderated somewhat the view of the medical profession, but we fear that the constant opposition in the past has predetermined the course which the government will follow in meeting the health demands of the Army as well as those of industrial and civil communities; namely, toward control of that service during the war emergency for Army, industrial and civil security and, in the post-war period, for civil social security.

In any event, it appears to us that the health services will be drafted into the military and industrial fields, particularly since the recent hesitancy of the medical profession to volunteer in sufficient numbers to meet the demands. The medical profession, with most praiseworthy motives, assured the army authorities that the volunteer system would serve the present purpose, and the Procurement and Assignment Service was in-

augurated to provide against any disturbance of the even tenor of the medical profession. However, the procurement was so insufficient and the assignment so retarded that the governmental Army circles lost patience with the effort, and Mr. McNutt only recently presented to the medical profession the ultimatum that if the needed medical service man power was not immediately forthcoming, the need would be met by a more productive, if less considerate, method of procedure.

In this suggested alternative procedure, we sense the first step toward government control of health service, which, on the ground of political expediency, can be very readily extended to the post-war period. Such an outcome may be condoned as an expeditious way of handling a difficult problem, but we do not believe that it can possibly be for the betterment of health service. We do believe, however, that it is and will be futile to oppose such an eventuality in the manner in which organized medicine has opposed it. And, incidentally, we are pleased to note that the attitude of the dental profession toward solving the health problem of the government has been one of helpful cooperation.

We do not attempt to offer a remedy or a better way out of the present difficulty, but we do believe that, other things being equal, the dental profession should endeavor to aid the government in its effort to solve the problem, rather than to oppose it; that the dental profession should be foresighted enough to work out a plan that will meet the situation without seriously interfering with the traditions of patient and professional relationship.

The American Dental Association has given an earnest of its spirit of cooperation with the government in the health field by the establishment of a committee which has for its ultimate objective the perfection of a plan for dental health service that will place dentistry within the means of every individual.

The needs of the Army in dental health service have so far been met admirably, and we do not anticipate any serious difficulties in meeting the demands of an army as large as is now proposed; but we fear that, in meeting this demand, the need in civil circles for adequate dental service will be greatly increased.

We do not like to appear to be calling "wolf" too often in this situation, but we would once more urge the necessity and the desirability of remedial and precautionary steps by the profession toward averting the control of the lifelines of the population by interests that are bound by the shackles of political expediency.

NORTHERN OHIO DENTAL ASSOCIATION DISBANDS

AFTER a distinguished career of eighty-five years as one of the noted pioneer society organizations in dentistry, the Northern Ohio Dental Association has reluctantly decided to discontinue its professional activities.

The Northern Ohio Dental Association was organized at Cleveland, Ohio, November 3, 1857. Just as the old Mississippi Valley Association of Dental Surgeons was a sectional society, covering many of the states in the Mississippi Valley (organized August 13, 1844, discontinued April 15, 1896), so was the Northern Ohio, covering most, if not all of the counties of the northern part of Ohio. In fact, it had many members from various counties in other sections of the state.

After the reorganization of the state into component societies of the state society, with the state society as a component of the American Dental Association, the membership was gradually absorbed into the state components. Each member of the Northern Ohio Association joined the component society that held jurisdiction over his territory, or he could not become a member of the state society. This reorganization was in reality the death knell of the Northern Ohio organization. Interest in it began to lag, and it seemed to have served its purpose, which was a commendable one.

Of late years, the Cleveland Dental Society, a component of the state society, has held its spring meetings in May, the month in which the Northern Ohio Dental Association had held its annual meetings, and this proved to be the fatal blow since the Cleveland Dental Society held unusually good meetings. The spirit seemed to prevail among Cleveland men that the Northern Ohio organization had served its purpose.

This pioneer organization originated in response to a resolution of the American Dental Convention in 1855, recommending organization of local societies. It served the profession of Northern Ohio throughout a period of development and progress which signalized the advancement of dentistry to its present high status.

Ohio is indeed rich in its dental heritage and the Northern Ohio Dental Association contributed much to that heritage. Among the organizers and promoters of the association are the names of men who have contributed much to dental history—George Watt, W. H. Atkinson, Benjamin Strickland, F. S. Whitslar, W. H. Whitslar, N. H.

Ambler, H. L. Ambler, George H. Wilson, Henry Barnes, L. P. Bethel, L. L. Barber and others.

In addition to the galaxy of famous dentists that she has given to dentistry, the Northern Ohio Dental Association has to its everlasting credit the establishment of the memorial shrine to dentistry at Bainbridge, Ohio, dedicated to early dental educational effort in America.

DEATH OF DR. OATHER A. KELLY

IT is with much sadness that we announce the sudden death of Dr. Oather A. Kelly, of St. Louis, Mo., September 11.

An obituary notice of Dr. Kelly will be published in an early issue of THE JOURNAL.

BIBLIOGRAPHICAL

War Medicine

Edited by WINFIELD SCOTT PUGH, M.D. Commander (M.C.) U.S.N. Retired. Cloth. 565 pages. Price $7.50. Illustrated. 1942. Philosophical Library, New York.

THIS interesting volume consists of fifty-seven individual sections on various phases of war medicine and surgery, by various authors. There are thirty-three articles on war surgery ranging from general organizational details of the field hospital to the treatment of various types of war wounds. Included in this group is a short section on the first aid and emergency treatment of gunshot wounds of the jaws, contributed by Robert H. Ivy. Certain of the chapters have been prepared by members of the British Army and Navy Services, and their additional practical experience in medical problems under actual conditions of warfare is particularly valuable. Ten articles are presented on aviation and naval medicine, including excellent summaries on physiology and high altitude flying, the medical aspects of deep sea diving and the problem of fatigue in aircraft pilots, which, according to the statistics presented, accounts for more casualties than does enemy gunfire. There are, finally, fourteen chapters on various medical problems peculiar to the Army, such as march foot. While this book will be of greater interest to physicians than to dentists, the material is sufficiently fundamental and broad in scope to provide stimulating reading to those interested in this rapidly developing phase of medicine.

F. F. K.

The Rockefeller Foundation—A Review for 1941

By RAYMOND B. FOSDICK, President of the Foundation. The Foundation publishes an annual report containing complete statements for the year by the secretary, the treasurer and the directors of the various fields of work. It also issues a separate annual report of the work of the International Health Division. Copies of these reports will be sent to any one applying for them.

Report of the Surgeon General, U. S. Army, to the Secretary of War, 1941

ANNUAL Report, War Department, Fiscal Year Ended June 30, 1941. United States Government Printing Office, Washington. 1941. For sale by the Superintendent of Documents, Washington, D. C. Price 30 cents.

ASSOCIATION ACTIVITIES

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WAR SERVICE COMMITTEE

COMMITTEE ON MATERIALS, SUPPLIES AND EQUIPMENT

STAINLESS STEEL MATERIALS MADE AVAILABLE FOR DENTISTRY

War Production Board
Washington, D. C.

Dr. George M. Anderson
831 Park Avenue
Baltimore, Maryland

Dear Dr. Anderson:

You will be glad to learn that the matter of making stainless materials available for use in orthodontia has been favorably concluded.

The mechanics for obtaining this material will be as follows. The supply house or distributor who deals directly with the manufacturer of these materials may apply for priority assistance on form PD-1-A and then sell to the dentist, school, clinic, etc., on a preference rating of A-10 under order P-100. Copies of P-100 are included, in case you are not familiar with this order.

We trust that your committee will take care of dispersing this news and we would also appreciate your including a personal admonishment for the doctors to refrain from purchasing more than their actual requirements, which we will try to make available to them at all times.

Very truly yours,

HERBERT B. SHOR, *Analyst*
Dental & Orthopedic Section
Health Supplies Branch
Division of Industry Operations.

GEORGE M. ANDERSON, *Chairman*
HARRY BEAR
HENRY SWANSON
A.D.A. Committee on Materials, Supplies and Equipment.

PROCUREMENT AND ASSIGNMENT SERVICE

IN an effort to clarify the function of the Procurement and Assignment Service for physicians, various questions and answers have been formulated by Frank H. Lahey, M. D., chairman. In the main, the questions, even though compiled for physicians, apply equally to dentists.[1]

Q. Will the Procurement and Assignment Service protect a dentist from the draft?

A. The Procurement and Assignment Service was not established to protect anybody from anything. Its function is to enroll physicians, dentists and veterinarians and assign them to the positions in which their services will be of greatest value to the nation in the war emergency. This function obviously parallels the responsibilities of selective service, but the officials of the Selective Service have welcomed the cooperation of the Procurement and Assignment Service in dealing with these professional groups. To implement this cooperation, General Hershey issued a memorandum to selective service boards asking them to secure through the state director of selective service the recommendations of the Procurement and Assignment Service where ever they are considering the classification of a physician, dentist of veterinarian. Hence, if a dentist has enrolled with the Procurement and Assignment Service, his selective service board will be so advised and a recommendation for his deferment, until his services are

1. *J.A.M.A.*, 119:888, July 11; 1113, August 1, 1942.

needed in a professional capacity, will be made.

Q. If a dentist is physically disqualified for a commission, is he still subject to the draft?

A. The physical requirements for officers are higher than they are for enlisted men, but under the modified requirements for "limited service" in the Dental Corps most, if not all, dentists who meet the requirements for enlisted men will be eligible for commissions. If not, the dentist concerned should consult the chairman of his state procurement and assignment service committee relative to service in a war industry or some other essential civilian service.

Q. Is the local draft board or the Procurement and Assignment Service to determine whether a dentist is necessary in his local community?

A. The legal responsibility for deciding whether any individual who is registered with Selective Service shall be given deferment rests with his local selective service board. However, General Hershey has directed local boards, when considering the classification of physicians, dentists or veterinarians, to secure the advice of the state committee of the Procurement and Assignment Service as to whether the individual under consideration is "essential" for the care of the civilian population in his community or whether he can be considered available for service elsewhere.

ARMY DENTAL CORPS PROMOTIONS

(RANK FROM FEBRUARY 1, 1942)
TEMPORARY PROMOTIONS

LIEUT. COLONEL TO COLONEL

Lieut. Colonel Lynn H. Tingay
Lieut. Colonel Thomas L. Spoon
Lieut. Colonel Roy A. Stout
Lieut. Colonel Roy L. Bodine
Lieut. Colonel Thomas J. Cassidy
Lieut. Colonel Walter A. Rose
Lieut. Colonel Avery G. Holmes
Lieut. Colonel Joseph L. Boyd
Lieut. Colonel Harry E. Smalley
Lieut. Colonel Clement J. Gaynor
Lieut. Colonel William B. Stewart
Lieut. Colonel Edward C. Alley

MAJOR TO LIEUT. COLONEL

Major James H. Pence
Major Marvin E. Kennebeck
Major Walter E. Chase
Major Tyler J. Walker
Major Wallace J. Morlock
Major Kenneth P. Fulton
Major Mackey J. Real
Major James H. Pence
Major Luster F. Best

CAPTAIN TO MAJOR

Captain Charles Max Farber
Captain George H. Timpke
Captain Clyde T. Oatman
Captain Robert B. Loos
Captain Cephas William Gary
Captain Harold E. Dilley
Captain William Harold Day
Captain Donald M. O'Hara
Captain William Paxton Fly, Jr.
Captain Virgil G. Walker
Captain Walter N. Graham
Captain Elbert LaF. Fenske
Captain (temp.) Reginald J. Fallis
Captain (temp.) Donald L. Cook
Captain (temp.) George H. Moulton
Captain (temp.) Franklin S. Lister
Captain (temp.) Thomas R. Haddock
Captain Richard J. Burch
Captain Willard L. Nielsen
Captain Albert C. Eskin
Captain Ethan A. Peterson
Captain Clarence T. Richardson
Captain Howard A. Rose
Captain Jasper R. Signorelli
Captain Joe Martin Cook
Captain Jesse M. Gee

Captain August R. Huberwald
Captain Theodore M. Peterson
Captain Maurice P. Ryan
Captain Howard B. Sherrod
Captain Lewis H. Guy
Captain Leslie C. Simpkins
Captain Charles S. O'Grady
Captain Clyde L. Sloss
Captain Dwight L. Baldridge
Captain Harold R. Finney
Captain Donald E. Riedl
Captain Robert L. Aubert
Captain Howard William Swartz
Captain Hermann G. Janssen
Captain Williams A. Ferguson
Captain Howard P. Schor
Captain Lloyd L. Boyer
Captain Claude R. Mauzy
Captain Kenneth J. Grimes
Captain Meseke O. Gephart
Captain Frank F. Enck
Captain Nicholar J. Altiero
Captain Raymond J. Hodapp
Captain Charles E. Williams
Captain James L. Key
Captain Louis F. Cherry
Captain William L. Allen
Captain Arthur Marks

1ST LIEUT. TO CAPTAIN

Lieut. Francisco F. Levinson
Lieut. Homer M. Luburgh
Lieut. Samuel F. Maurer
Lieut. Peter W. Maximuke
Lieut. Evan D. Morgan
Lieut. William M. Sloop
Lieut. Aubrey J. Smith
Lieut. Barnard B. Gilden
Lieut. Philip M. Fogle
Lieut. Dimitri Filostrat
Lieut. Karl F. Ehrlich
Lieut. John William Butler
Lieut. Donald F. Berry
Lieut. Murray O. Anderson
Lieut. Morris H. Kornblum
Lieut. William C. Smedley
Lieut. Claude Phillips
Lieut. Dee C. Pennington
Lieut. Maurice A. Meador
Lieut. Harold L. Massey
Lieut. James A. Lyon
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Lieut. Donald McGregor
Lieut. Julius Holpern
Lieut. Gerald D. Howe
Lieut. Claud R. Armistead
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Lieut. Carlos Weil
Lieut. John D. Rosenfeld
Lieut. Samuel Miller
Lieut. Edward S. Harris
Lieut. Bernard Solomon Feinberg
Lieut. Richard B. Ball
Lieut. Sidney Smith
Lieut. Theodore Levine
Lieut. Nathaniel A. Yuckman
Lieut. Donald C. Allbee
Lieut. Hamilton R. Young
Lieut. Robert E. Wilson
Lieut. Ford W. Stevens
Lieut. William H. Stepp
Lieut. Roland T. Sedgwick
Lieut. Charles S. Rivers
Lieut. Alfred B. Oxford
Lieut. Hildreth A. Hannett
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Lieut. William B. Dinneen
Lieut. Bernard Rosenblat
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Lieut. Raymond H. Donley
Lieut. Howard C. Malek
Lieut. Paul V. Keller
Lieut. Eugene J. Brown
Lieut. William T. Shepherd
Lieut. Darrell M. Walters
Lieut. John H. Mitchell
Lieut. Orison F. Miller
Lieut. Albert D. Mercker
Lieut. Fred W. Leavell
Lieut. Armand W. Johnson
Lieut. William B. Clifford
Lieut. Frederick L. Conrad
Lieut. Manuel G. Cramer
Lieut. Anselm L. Danitz
Lieut. Michael J. Eyen
Lieut. Sanford A. Lipford
Lieut. Charles J. Hoff
Lieut. Luther Hayden Hale
Lieut. Morton Lucas
Lieut. Wallace C. Mayo
Lieut. Bernard C. Perlman
Lieut. Michael S. Varipatis
Lieut. Simeon J. Waits
Lieut. George N. Schulte
Lieut. William B. Silvern
Lieut. Charles M. Kleinhrizen
Lieut. Allen W. Porter
Lieut. Raymond L. Roof
Lieut. Morris L. Biderman
Lieut. William A. Beetham
Lieut. Perry D. Straup
Lieut. Rollin C. Avenell
Lieut. Wallace W. Barr
Lieut. Louis Bellegante
Lieut. John S. Cain
Lieut. Kendrick Brookreson
Lieut. Otha W. Boyer
Lieut. James L. Bock
Lieut. Henry C. Fixott
Lieut. Andrew S. Fonts

Lieut. Jose R. Goenaga
Lieut. Jess M. Harris
Lieut. Howard B. Johnson
Lieut. Sheldon R. Kemp
Lieut. Frederick C. Lord
Lieut. Donald P. McCutchen
Lieut. Robert M. MacCraw
Lieut. Amos O. Pilgrim
Lieut. John W. Potter
Lieut. George D. Sturgeon
Lieut. John F. Shaeffer
Lieut. William W. Senn
Lieut. Elmer T. Schaberg
Lieut. Toby Weinshenker
Lieut. Richard H. Clay
Lieut. Paul A. Dunbar
Lieut. Philip Eckel
Lieut. Kenneth P. Eiffert
Lieut. Edgar B. Erard
Lieut. Harold P. Essner
Lieut. Morris Freedman
Lieut. Frank F. Freimuth
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Lieut. John C. Kouns
Lieut. Arnold J. Levine
Lieut. William F. Maxwell
Lieut. Donald R. Shaw
Lieut. William Bole Smith
Lieut. Theodore S. Martin

BUREAU OF PUBLIC RELATIONS

"THE KEYS TO HEALTH AND HAPPINESS"

NEW SLIDE FILM FOR LAY EDUCATION

BETTER health through better dental hygiene is the objective of the Dental Hygiene Institute of Chicago, a non-profit civic organization set up about a year ago to carry out a long needed active program of lay education in this field. The institute, which is endorsed and actively supported by the Chicago Dental Society, its professional activities supervised by a committee of dentists nominated by the society, has embarked upon an ambitious program.

Believing that seeing is one of the most potent means of presenting a convincing story, one phase of the institute's work is the production of slide films and motion pictures on the subject of good dental care. Its first undertaking, a sound slide film called "The Keys to Health and Happiness," has been completed and is

Fig. 1.—Dental care—or rather the lack of it—disturbs the family harmony.

Fig. 2.—"I don't want to see anybody and I don't want anybody to see me."

being shown to interested groups of laymen in the Chicago area.

A slide film, it may be explained, consists of a series of still pictures on a roll of film comparable to motion picture film. Each section is shown as a regular lantern slide, successive pictures being projected on the screen and held there temporarily to the accompaniment of dialogue or the narrator's description, and the sound coming from a record-player built into the projector. Thus, seeing and hearing are simultaneously employed in this educational medium.

"The Keys to Health and Happiness," which was produced at a cost of $2,000, tells a complete story, in dramatized form, of the troubles of the Davis family and how they were corrected by dental

Fig. 3.—"Doctor, can my teeth really be straightened?"

care. It tells the story of little Anne, who was broken hearted because her crooked teeth had excluded her from a part in the school pageant; of Mrs. Davis who was nervous and irritable because of infected teeth, and how the whole family situation had Henry Davis so upset that he didn't get the coveted position of sales manager of his company. The running time is twenty-three minutes.

The presentation is non-technical and easily understood by the lay public. It stresses, in a positive and entertaining manner, what dentistry can do for the individual through better health and better appearance. Home care of the mouth, proper diet and care in the dentist's office are emphasized. The story does not overlook the patient's fear of pain and the expense of dental care, but explains how these will be less if the teeth are examined at regular intervals by a dentists.

The film was produced by the Chicago Film Laboratory, Inc. Only professional talent was used, including actors, narrator and script writers. Hence, the presentation has the ring of conviction which only professionals can impart.

The Dental Hygiene Institute is showing the film without charge to lay audiences such as women's clubs, parent-teacher associations, lodges, church groups and business women's clubs; also to some men's organizations such as the Kiwanis and Lions clubs—all excellent groups before which to place dentistry's case in the interest of a healthier and happier community.

The institute's field representative goes to each meeting, taking the projection equipment with her, and assumes charge of the program. Because it has been found that questions from the floor following showings of the film are such that no one but a dentist should attempt to answer them, it is usually arranged that a dentist be present at each showing to answer the questions and conduct a round-table discussion. Audience response has been enthusiastic and bookings are coming in at a gratifying rate.

While the Dental Hygiene Institute is showing the film only in Chicago and the adjacent suburbs in Cook, DuPage and Lake Counties, prints of the film and the necessary recording can be purchased by local dental societies and public health agencies outside of Chicago at a cost of $25 for both. Inquiries should be addressed to the Dental Hygiene Institute of Chicago, 30 North Michigan Ave., Chicago, Ill. Projection equipment usually can be rented or borrowed, and many schools are equipped with sound projectors.

EXPENDITURES BY STATE AGENCIES FOR MEDICAL AND DENTAL CARE

THE August 21, 1942 issue of *Public Health Reports* carries a lengthy article by Joseph W. Mountain and Evelyn Flook on state expenditures for medical and dental care. A table showing the approximate total and per capita annual expenditures by all official state agencies for medical and dental care is herewith reproduced, as it is very illuminating.

The report states that at the time of

APPROXIMATE TOTAL AND PER CAPITA ANNUAL EXPENDITURES* BY ALL OFFICIAL STATE AGENCIES FOR MEDICAL† AND DENTAL CARE IN EACH STATE AND TERRITORY, THE DISTRICT OF COLUMBIA, AND THE VIRGIN ISLANDS, AND PERCENTAGE DISTRIBUTION ACCORDING TO TYPE OF CARE.

State or Territory	Approximate Annual Expenditure* for Medical and Dental Care		Percentage of Reported Total Expenditure Devoted to Specific Type of Care			
	Total	Per Capita	Psychiatric Services	Services for Crippled Children	General and Other Allied Special Medical Service	Dental Service
Total	$190,653,400	$1.42	76.0	4.8	19.0	0.2
Alabama	1,320,100	0.47	87.0	13.0	(a)	(a)
Arizona	433,800	0.89	77.8	20.7	1.5	.....
Arkansas	1,382,200	0.71	65.6	9.5	24.4	0.5
California	8,379,100	1.21	84.0	3.3	12.7	(a)
Colorado	2,532,800	2.26	53.5	3.8	42.7	(a)
Connecticut	3,457,200	2.02	87.0	3.9	9.1	(a)
Delaware	595,700	2.24	99.7	(a)	(a)	0.3
District of Columbia	1,304,000	2.06	2.0	1.3	96.7	(a)
Florida	1,790,100	0.94	92.2	7.3	(a)	0.5
Georgia	1,694,300	0.54	87.4	9.6	2.5	0.5
Idaho	366,100	0.70	100.0	(a)	(a)	.....
Illinois	14,528,200	1.80	65.3	4.1	30.3	0.3
Indiana	6,172,900	1.80	84.7	2.5	12.8	(a)
Iowa	3,667,700	1.44	55.5	5.1	38.8	0.6
Kansas	2,145,600	1.19	65.7	12.2	21.9	0.2
Kentucky	1,408,500	0.50	84.7	13.1	1.5	0.7
Louisiana	4,456,600	1.88	32.1	0.2	67.7	(a)
Maine	1,332,100	1.57	81.7	5.3	12.1	0.9
Maryland	2,396,400	1.32	49.1	4.4	46.1	0.4
Massachusetts	9,281,800	2.15	75.9	4.2	19.9	(a)
Michigan	8,455,800	1.61	80.9	10.4	8.5	0.2
Minnesota	4,261,300	1.53	66.1	6.8	27.0	0.1
Mississippi	1,219,900	0.56	59.1	5.9	33.9	1.1
Missouri	3,516,100	0.93	95.3	3.8	0.9	(a)
Montana	681,100	1.22	74.7	11.2	14.1	(a)
Nebraska	1,338,100	1.02	89.7	10.3	(a)	(a)
Nevada	90,500	0.82	93.0	2.2	(a)	4.8
New Hampshire	1,163,600	2.37	86.6	2.1	11.3	(a)
New Jersey	7,994,300	1.92	88.4	1.6	10.0	(a)
New Mexico	379,100	0.71	60.0	20.8	19.2	(a)
New York	35,952,200	2.67	95.5	2.9	1.6	(a)

North Carolina	1,692,800	0.47	81.2	12.5	(a)	6.3
North Dakota	1,270,400	1.98	75.1	5.6	19.3	(a)
Ohio	7,170,100	1.04	82.5	2.6	14.9	(b)
Oklahoma	2,545,600	1.09	59.8	17.4	22.3	0.5
Oregon	1,246,500	1.14	88.6	9.3	1.8	0.3
Pennsylvania	17,376,800	1.76	54.0	2.0	43.9	0.1
Rhode Island	1,470,700	2.06	73.7	2.9	23.4	(a)
South Carolina	2,652,200	1.40	95.5	4.5	(a)	(a)
South Dakota	899,500	1.40	74.8	5.0	20.2	(a)
Tennessee	1,174,100	0.40	85.2	12.4	(a)	2.4
Texas	3,728,600	0.58	89.8	9.4	0.4	0.4
Utah	570,400	1.04	84.6	11.6	2.3	1.5
Vermont	575,500	1.60	91.1	6.3	2.6	(a)
Virginia	3,691,800	1.38	62.7	3.8	31.9	1.6
Washington	2,156,300	1.24	95.4	4.6	(a)	(a)
West Virginia	1,707,000	0.90	43.5	11.2	45.3	(a)
Wisconsin	4,377,600	1.40	63.6	8.1	28.2	0.1
Wyoming	270,900	1.08	80.4	10.0	9.6	(a)
Alaska	19,400	0.27	.....	100.0	(a)	(a)
Hawaii	1,130,900	2.67	40.3	3.9	51.1	4.7
Puerto Rico	1,116,100	0.60	19.8	(a)	80.2	(a)
Virgin Islands	103,000	4.14	7.6	.....	88.2	4.2

*Expenditures for the services considered represent index rather than absolute amounts. Because of variations in fiscal practices, figures cover the most recent year for which information was available at the date of interview. In some instances, because of overlapping and interweaving of activities, estimates were accepted in the absence of precise expenditure records. All funds disbursed by official state agencies for programs chiefly consisting of medical care are included irrespective of their source. State-appropriated moneys constitute 90 per cent of the total; funds from local taxing bodies, 5 per cent; fees from patients and private contributions, 3 per cent; and Federal grants-in-aid, 2 per cent.

†So far as they could be identified, figures for medical care include psychiatric services, services for crippled children, general medical care of the needy, cancer service, pneumonia service, prevention and correction of blindness, and health services for migratory labor.

(a) Expenditures for this service as a separate activity were not procurable, and therefore are not a part of the amount listed in the column "Total."

(b) Less than 0.1 per cent.

this survey, the state health departments, with but few exceptions, were giving some attention to the possibility of improving their citizens' dental health. In addition, ten departments of welfare; five state universities; four departments of education, and one state hospital board also contributed in one way or another to the total state effort to preserve or restore dental health. To a marked degree, the state health departments confine their dental activities to children's dentistry, most of which is of an educational nature. The operation of direct service facilities is subsidiary to the teaching functions.

Fully two-thirds of the $285,715,800 expended for composite state health services is charged to health programs which, primarily, are identified with maintenance of facilities for correction or care of mental and physical disabilities. Expressed otherwise, more than $190,000,000 is disbursed annually by agencies of the state government for health activities in which medical or custodial care is the preponderant component. (See accompanying table.)

This figure is exclusive of medical bnefits paid through workmen's compensation channels and of expenditures for tuberculosis and venereal disease which also involve a considerable amount of medical care.

DENTISTRY IN THE MAGAZINES

Diet Digest, the attractive and inexpensive little magazine published quarterly under the editorship of Gayelord Hauser, is playing an important part in the national nutritional program. As can be judged by its title, *Diet Digest* confines itself exclusively to articles on diet and nutrition, which it prints in an interesting and readable form. Dentists should be particularly interested in *Diet Digest* because each issue usually contains one or more articles on dentistry. The current issue carries three short articles, "A Town Where No One Ever Has a Toothache"—you guessed it: Hereford, Deaf Smith County, Texas; "Your Teeth and Your Diet," by Lon W. Morrey, and "Your Food and Your Teeth" by Gayelord Hauser. Hauser says:

> The teeth have a most important place in beauty make-up—first of all the smile—it brightens up the face—but only if the teeth are strong and healthy. Next the contour of the lower face—the teeth decide what that contour will be—finally, look at your skin, eyes and figure—the teeth prepared the food for digestion—so it can be used by the body cells. Without healthy teeth the result is, very often, indigestion and constipation with all their unfortunate effects on your looks."

If your patients won't believe you, let them read what Hauser has to say on the subject.

Several other timely articles on dentistry have appeared recently in current magazines. In "Health and Total War," W. S. Kelly and Harold Hillenbrand informed the April *Kiwanis* readers the world over of the important part that the dental and medical professions are playing in the total war now gripping the universe.

May *Hygeia* published James Miller's "Healthy Teeth for Uncle Sam's Children," and the New York State *Health News* published "Recent Research in the Field of Dental Caries." *Health Culture Magazine* published "Health Is What You Make It," by Paul H. Belding, and *Public Health Nursing* published Harry Lyons' article on "Vincent's Infection of the Mouth."

Mention must also be made of Robert Benchley's controversial article "Nothing but the Tooth" in the May issue of *Reader's Digest*.

The June issue of *Hygeia* not only carries "Advice to the Dentally Feeble," by Margate Kienast, but "Dental Defects and Nutrition," by Lieut.-Col. Amos R. Koontz.

Capper's Farmer published "Baby Teeth," by Beulah France, R. N., and the *Army Times* printed Sergeant Nathan Kaplan's "Shelby Dentist Expert on Tooth Crutches."

Health articles are often found in strange and unexpected places. For instance, the *Hercules Mixer* published Lemuel C. McGee's "Since Your Best Friend Won't Tell You," a very interesting article on *fetor oris*.

"Tips on Tooth Powders," by Winea J. Simpson, appeared in the June issue of *Health*. William R. Davis' "Early Diagnosis of Pyorrhea Is Essential to Successful Treatment" was published by *Michigan Public Health*, while the Raleigh, N. C. *Health Bulletin* carried W. Yates League's "And She Cried All Night." In July, *The Progressive Farmer and Southern Ruralist* carried Sally Carter's "Keep Smilin,'" while *Hygeia* published Fred D. Miller's "Eating for Sound Teeth."

COUNCIL ON DENTAL THERAPEUTICS

ACCEPTED DENTAL REMEDIES

The Council on Dental Therapeutics of the American Dental Association announces the inclusion of the following article in the list of Accepted Dental Remedies.

Zephiran Chloride: A brand of benzyl trialkonium chloride, a mixture of alkyl dimethyl benzyl ammonium chlorides conforming to the general formula $C_6H_5CH_2N(CH_3)_2$ RCl, in which R represents a mixture of alkyl radicals from C_8H_{17} to $C_{18}H_{37}$ as contained in the corresponding fatty acids of coconut oil. The fatty acids of coconut oil are converted to alcohols and the latter to chlorides, which are then converted by dimethylamine to the corresponding amines, which in turn are combined with benzyl chloride to form the quaternary compound.

PROPERTIES: Zephiran chloride occurs as a colorless or slightly yellow gelatinous semisolid with a slight aromatic odor and an acid taste, usually containing from 10 to 20 per cent water. It is miscible with water, acetone and alcohol in all proportions, slightly soluble in cold benzene and insoluble in ether. The aqueous solution shows a slightly alkaline reaction to litmus. Zephiran chloride is incompatible with soap. With some salts of heavy metals, it forms precipitates not readily soluble.

ACTIONS AND USES: An aqueous solution of alkyl dimethyl benzyl ammonium chlorides possesses bacteriostatic and bacteriocidal properties against non-sporulating organisms. It is claimed to be useful in maintaining asepsis of previously sterilized instruments such as hypodermic equipment and in the disinfection of dental instruments. Studies on guinea-pigs and on rabbits indicate that the product is relatively non-poisonous and non-toxic. Administration of the 1:1,000 concentration by mouth to guinea-pigs had no deleterious effect over a feeding period of several months. Rabbits tolerate 1.2 cc. per kilogram of body weight of the 10 per cent solution when it is administered subcutaneously or intraperitoneally.

It is claimed that alkyl dimethyl benzyl ammonium chloride in proper dilution is non-irritating to the skin and mucous membrane. The use of the aqueous solution as an antiseptic agent for the oral mucous membrane is still in the experimental stage.

For further tests of identity and purity, see N.N.R. 1942.

DOSAGE: For cold disinfection of instruments, Zephiran Chloride 1:1,000 aqueous solution; for maintaining sterility of hypodermic equipment, Zephiran Chloride 1:2,000 aqueous solution; for disinfection of rubber gloves, Zephiran Chloride 1:2,500 aqueous solution; for disinfection of utensils, operating table and cabinet tops, Zephiran Chloride 1:5,000 aqueous solution.

Manufactured by Alba Pharmaceutical Co., Inc., New York, N. Y. Distributed by Cook-Waite Laboratories, Inc., New York, N. Y. U. S. Patents No. 2087131, 2087132, 2086585. U. S. Trademark No. 333899.

Zephiran Chloride Solution 1:250: Zephiran chloride, 0.4 per cent; water, 99.6 per cent.

Zephiran Chloride Solution 1:1,000: Zephiran chloride, 0.1 per cent; water, 99.9 per cent.

Admission of an article to the list of Accepted Dental Remedies does not imply a recommendation. Information regarding the rules and work of the Council will be sent on request.

DONALD A. WALLACE, *Secretary.*

RESEARCH COMMISSION

REPORT OF THE RESEARCH COMMISSION

(1941-1942)

To the Officers, Board of Trustees and House of Delegates of the American Dental Association:

WAR conditions have altered the programs of research established by the Research Commission. Owing to the increase in defense work at the National Bureau of Standards, it has been necessary to curtail our research program there. To a certain extent, this was accomplished by natural conditions, our Senior Research Associate, George C. Paffenbarger, having been called into active service as lieutenant commander in the U. S. Navy. Dr. Paffenbarger is now stationed at the U. S. Naval Medical Supply Depot, Brooklyn, N. Y., in charge of dental materials research. William T. Sweeney left our employ in August 1941 to fill a position with the Vernon-Benshoff Company as chief of their research activities. Thus, only two research workers (John R. Beall and H. J. Caul) are left at the Bureau of Standards. Although the Commission was anxious to replace Dr. Paffenbarger and Mr. Sweeney, the authorities at the Bureau requested that we wait until a time when they would not be so occupied with work connected with the war program.

Because of the war situation, our fellowship in dental diseases at the National Institute of Health has become of increasing importance and it will be necessary to take on additional personnel during the coming year. It is fortunate that our program of research began with a study of Vincent's disease. By commencing this study last September, the needs of the nation were anticipated by three months; for it will undoubtedly be found that, with the declaration of war in December, the incidence of Vincent's disease increased. The large concentrations of men from all walks of life will be an important contributing factor. Reports emanating from England since the war reveal that not only are troops infected with this disease, but munition workers and civilians also. Improper diet, worry and lack of sleep due to overwork and air raids are factors. It is believed that our investigations will prove of great value.

At the present time, our research associate, E. G. Hampp, is working to develop a satisfactory cultural method for isolating the spirochetes of Vincent's disease, for which no adequate method has been discovered to date. His progress indicates that he will perhaps solve this problem. As the program of research in Vincent's disease gains momentum, it may be necessary to take on an additional research worker and the Commission is now endeavoring to find the right man for this work. Furthermore, we desire to find a worker this year to undertake the investigation of dental caries, a project which, it is hoped, we will soon be able to make a part of our permanent program. In view of this fact, we are requesting an increase in our appropriation for the work at the National Institute of Health. Because our appropriation at the National Bureau of Standards will be curtailed, it is hoped that the Board will see fit to transfer this money to the fellowship in dental diseases, since this work will be of great importance to our national war program as well as to the profession in general.

The book "Dental Caries," compiled by the Advisory Committee on Research in Dental Caries, has been selling regularly since its publication in September 1941. When all copies of this book have been sold, the returns to the American

Dental Association will be sufficient to compensate for the appropriations made for this work. At the same time, "Dental Caries" has given the work of the American Dental Association tremendous prestige and has rendered a valuable service to dental caries research throughout the world.

Another book which the Research Commission takes pride in being associated with is "Physical Properties of Dental Materials," Circular C433, published by the United States Government Printing Office, to sell at 75 cents. The authors of the book are Wilmer Souder, of the National Bureau of Standards, and George C. Paffenbarger, our former Senior Research Associate. This book presents a summary of all work done in dental materials research at the National Bureau of Standards since its commencement in 1919. The Research Commission is proud of its contribution to this work since 1928, when our fellowship was established. It is felt that this book will have a great influence on the teaching of the subject in dental schools.

REPORT OF THE AMERICAN DENTAL ASSOCIATION RESEARCH FELLOWSHIP AT THE NATIONAL BUREAU OF STANDARDS—FELLOWSHIP OR PHYSICAL AND CHEMICAL RESEARCH IN DENTAL MATERIALS

The loss to the fellowship of W. T. Sweeney and George C. Paffenbarger has, of necessity, curtailed the work of the fellowship.

Our attention has been turned first to the maintenance of the list of certified materials and the certification program in general. During the past year, the various manufacturers have offered for certification forty-four products not previously on the lists. The results of tests of these materials are indicated in the accompanying table.

The importance of maintaining these lists of certified products is emphasized by the fact that the Government has inaugurated a policy wherein it demands that certain materials appear on these lists before bids are considered for the purchase of such materials.

A survey of the wrought gold alloy wires on the list of certified materials was completed. Eighteen alloys were included. One failed to meet the specification requirements and was removed from the list. With the addition of the six mentioned in the table, the list now includes twenty-three wires.

Complete chemical compositions were determined for the eighteen wires in the survey, as well as the mechanical properties evident after different heat treatments. The data thus accumulated served as the basis for a revision of A.D.A. Specification No. 7 for wrought gold alloy wires, which was prepared and submitted to the manufacturers, schools, members of the profession and other interested parties. Comments have been received which may necessitate additional investigation before the revised specification is offered for adoption.

At the completion of the survey of the wrought gold alloy wires, a survey of the inlay casting gold alloys was begun. As of June 1, tests were completed for sixteen type A, soft, alloys and fifteen type B, medium, alloys. Tests of the remaining five type A alloys and sixteen type B alloys were nearing completion, and samples of type C, hard, alloys had begun to arrive.

Work on amalgam during the past year has included determination of the mercury contents of amalgam specimens packed with different technics and the determination of the mercury content of different sections of the same sample using the method of analysis developed by H. J. Caul and I. C. Schoonover of the A.D.A. Fellowship and the Bureau staff, respectively.

Further investigations have been made in an effort to determine additional quantitative data on the delayed excessive expansion of amalgam when contaminated.

In connection with the study of contaminated amalgam, samples of two alloys were purchased, tested, repackaged and sent to a selected committee of cooperators, who were requested to place similar fillings of the two materials. Reports from these cooperators on the behavior of the two alloys in the mouth will be requested at intervals and compared with the laboratory data.

A preliminary report of a study of some base metal alloys used in prosthesis was prepared by G. C. Paffenbarger and George R. Dickson (of the Bureau Staff) and was presented by Dr. Paffenbarger at the National Meeting of the A.D.A. in Houston, Texas. The report included a program to determine, if possible, the relative wear of acrylic teeth. Models have been prepared of the completed dentures and will be compared with models made of the same dentures after suitable periods of time.

The following case will serve as an illustration of the miscellaneous functions of the fellowship during the year. A certain acrylic denture base material was on the market in packages which carried a statement guaranteeing compliance with A.D.A. Specification No. 12. This material had not been certified to the Commission in the regular manner, as outlined in a past report.[1] Reports that the material did not comply with the specification having been received, the Commission purchased a sample on the open market and sent it to the fellowship for testing. The results of the tests at the Bureau substantiated the reports that the material did not comply with all requirements of the specification. Correspondence has been initiated with the manufacturer relative to remedying the situation.

In such cases in the past, the manufacturer has been notified that his claims were false and misleading and that the material or advertising must be altered.

RESULTS OF TESTS OF MATERIAL FOR 1941-1942

Material	A.D.A. Specification Number	Number of Products Certified	Number of Products Passed	Number of Products Failed
Amalgam alloy	1	2	2	0
Impression compound	3	8	6	2
Inlay casting gold	5	7	7	0
Mercury	6	1	1	0
Wrought gold wire	7	6	6	0
Zinc phosphate cement	8	1	1	0
Hydrocolloidal impression material	11	1	1	0
Denture base material (acrylic resin)	12	18	13	5
Totals		44	37	7

mechanical properties, compositions and the effect of heat treatment. An exhibit of the work at the Bureau was also shown at the Houston meeting.

Tests of denture base resins, made in checking early certifications for compliance with the original form of Specification No. 12, indicated that changes in some of the test procedures adopted from A.S.T.M. tests would be desirable. The specification was revised in accordance with these indications and has been effective since January 1, 1942, in this revised form.

Dentures have been made by Luzerne G. Jordan for several patients, who have signified their willingness to cooperate in

1. Report of the Research Commission, American Dental Association. J.A.D.A., 26: 1723-1730, October 1939.

It has been necessary in only a few cases to refer the matter to the Federal Trade Commission. This again illustrates the importance of using the list of certified materials as a buying guide rather than reading advertisements or listening to unsubstantiated claims.

The following publications on the work of the Fellowship and the Bureau have appeared during the last year.

1. List of Certified Acrylic Denture Resins: Research Commission, J.A.D.A., 28:1166, July 1941.

2. Schoonover, I. C., and Souder, Wilmer: Corrosion of Dental Alloys. J.A.D.A., 28:1278, August 1941.

3. List of Certified Gold Wire Alloys. List of Certified Denture Resins: Research Commission. J.A.D.A., 28:1704, October 1941.

4. List of Certified Dental Impression Compounds: Research Commission. J.A.D.A., 28:1886, November 1941.

5. List of Certified Denture Resins: Research Commission. J.A.D.A., 28: 2046, December 1941.

6. Sweeney, W. T.; Paffenbarger, G. C., and Beall, J. R.: Acrylic Resins for Dentures. J.A.D.A., 29:7, January 1942.

7. Revised A.D.A. Specification No. 12 for Denture Base Material: Acrylic Resin or Mixtures of Acrylic and Other Resins. J.A.D.A., 29:127, January 1942.

8. Excessive Expansion of Amalgam: Research Commission. J.A.D.A., 29:292, February 1942.

9. List of Certified Dental Materials (as of December 1, 1941): Research Commission. J.A.D.A., 29:293, February 1942.

10. Souder, Wilmer, and Paffenbarger, G. C.: Physical Properties of Dental Materials. Circular of the National Bureau of Standards C-433. Issued February 6, 1942. United States Government Printing Office, Washington, D. C.

The necessary data have all been obtained and tabulated for papers on the properties of certain base metal alloys and on the delayed excessive expansion and other phenomena connected with the contamination of amalgam alloys. The manuscripts of these papers are in preparation.

The tentative program for the reduced staff of the Research Fellowship at the National Bureau of Standards includes the following items:

1. The testing of the materials on the Lists of Certified Materials to insure their continued high quality will be the primary function for the duration of the emergency.

2. As surveys of certified materials are made, desirable revisions in the specifications may become evident. The specifications will be altered when evidence warrants it.

3. Such substitutes as may be offered for materials withdrawn from use because of shortages will be investigated.

4. Checking of flagrant cases of false and misleading claims and advertising will be continued.

5. Periodic reports from the cooperating committee on amalgam will be requested and the data thus secured will be tabulated and incorporated in a report.

6. Measurements will be made at intervals on the experimental dentures now in service to evaluate the wear of acrylic teeth and the dimensional stability of the base material.

7. As time permits, investigation of the effect of technic and other variables on the properties of acrylic resins will be attempted.

Respectfully submitted,

JOHN R. BEALL,
Research Associate.

REPORT OF THE AMERICAN DENTAL ASSOCIATION RESEARCH FELLOWSHIP AT THE NATIONAL INSTITUTE OF HEALTH—FELLOWSHIP FOR BIOLOGIC RESEARCH AND DENTAL DISEASES

During the past eight months, the re-

search work on dental diseases consisted of an approach to the study of Vincent's stomatitis and the problem of ameloblastoma by the method of microincineration.

The theory regarding the etiology of Vincent's stomatitis is on a very unsatisfactory basis. The constant presence of large, delicate, loosely wound spirochetes in association with other morphologic types, as well as numerous fusiform bacilli, in such infections, has led to the belief that this symbiosis is the primary factor in the production of the disease. The isolation of the members of this combination is of primary importance before one can regard them as the etiologic agents. The fusiform bacilli have been isolated on numerous occasions, whereas the oral spirochetes have been a constant source of difficulty. *Borrelia vincenti* seems never to have been obtained in pure cultures. The smaller spirochetes have been reported in pure culture on few occasions, and some of this work has never been duplicated.

The few technics reported in the literature for the isolation of oral spirochetes have been reviewed and tried in the laboratory in addition to several modifications, technics and recently developed media. This was done with the thought of isolating one or more spirochetal strains for animal experimentation, to develop a medium for routine work and attempt to isolate *Borrelia vincenti*. At the present time, three strains of oral spirochetes have been isolated, none of which includes Vincent's spirochete. The experimental work on culture media and technic is still in progress.

Recent reports in the literature seem to indicate that various factors in the vitamin B_2 complex may be instrumental in lowering the resistance of the oral mucosa to infection in cases of ulceromembranous stomatitis. An experiment utilizing animals deficient in vitamin B on high carbohydrate, low protein and fat diet has been set up in which various members of the oral flora including the isolated spirochetes may be utilized both in combination and separately.

Recent reports from the British Isles indicate an increased prevalence of ulcerative stomatitis both in the armed forces and in industrial workers. The epidemiologic phases of this syndrome complex are also being studied by dental officers of the service on duty in this division, and plans are being made to collaborate with them in field epidemiologic studies incident to the investigation. Relatively complete epidemiologic studies of Vincent's infection have not to my knowledge been made, and pertinent leads for laboratory investigation may be brought to light by this method of study.

In addition to the problem of Vincent's infection, a study was made of an enamel-containing ameloblastoma. From studies of histologic sections, it has been assumed by many investigators that the cells comprising the ameloblastoma differentiate similarly to those of the true enamel organ, a finding which has been confirmed by the technic of microincineration. These findings were presented at the twentieth annual meeting of the International Association for Dental Research. The final manuscript was submitted to THE JOURNAL for publication.

Respectfully submitted,

E. G. HAMPP,
Assistant Dental Surgeon (R).

SUMMARY

Because of the disturbed international situation, the work of the Advisory Committee on Research in Dental Caries has been made difficult. Foreign correspondence is confined to the Western Hemisphere, with an occasional letter from Europe or Australia. This committee will continue its work during the war and, when hostilities are over, if it is thought that another survey of the field

of dental caries research is indicated, it will be made. In the meantime, it may be that this committee can be of some assistance in an advisory capacity to the various groups now considering programs for dental caries control.

In the cooperative research with the Research Commission, a substitute for tinfoil has been developed which is quite satisfactory for use in curing dental resins. A film of a soluble alginate is applied to the plaster. When it is dry, it is rendered insoluble and thus protects the resin during curing or molding. The substitute has advantages over tinfoil in that it is easier to apply, takes less time, and gives a smoother surface, and permits easier separation of the halves of the flask. A patent application has been filed with proper assignments to the Secretary of Commerce to protect the Government and the dental profession. The invention was perfected by Irl C. Schoonover and George R. Dickson, of the dental research staff of the National Bureau of Standards.

During the past year, the Commission received a grant of $250 from the American Full Denture Society for special research work on acrylic resins. This money was deposited with the Treasurer of the American Dental Association. Very little of it has been spent to date, and the Commission will not be in a position to make a report on this study until some time in the future.

The facilities of the dental laboratories of the National Bureau of Standards and of the American Dental Association Fellowship have been made available to the Dental Materials Committee of the A.D.A. and the War Production Board for consultation on current problems arising from shortages of certain materials. The question of the suitability of substitutes offered for products containing materials of which the supply is restricted has already arisen and the advice of the Bureau has been sought. As mentioned elsewhere in this report, one of the phases of the work of the A.D.A. Research Fellowship for the coming year will be the investigation of other substitute materials as the need for them occurs.

The Commission is concerned over the disruption of research in all fields of dentistry as a result of the war. Specially trained personnel is difficult to get even in peace times. It is felt that some effort should be made to protect dental research workers and prevent their being lost in clinical practice, either in the services or in civilian life. The Commission intends to make a survey of the dental research field of the available personnel. It is believed that research programs will be expanded at the end of the war and qualified men will be essential. A list of available trained research workers may prove of great value to all institutions engaged in dental research.

Respectfully submitted,
M. D. HUFF, *Chairman,*
DANIEL F. LYNCH, *Secretary.*

LISTS OF CERTIFIED DENTAL MATERIALS

(As of September 1, 1942)

THE A.D.A. Research Commission, in cooperation with the National Bureau of Standards, has developed specifications for the following materials: amalgam, inlay investment, impression compound, inlay casting wax, inlay casting gold alloy, mercury, wrought gold wire, zinc phosphate cement, silicate cement and hydrocolloidal impression materials.

Samples of the foregoing materials which were certified to the Research Commission by the various manufacturers as complying with the A.D.A. specifications were procured on the retail market by the Research Commission and were tested by the A.D.A. Research Associates at the National Bureau of Standards. The following certified materials were found to comply with the A.D.A. Specifications. Certified materials which did not comply with specifications are omitted from the lists.

Materials listed below are constantly being tested. Therefore, the lists are subject to revision from time to time. The revised lists will be published in THE JOURNAL.

A survey of the certified inlay casting gold alloys is now in progress. Although the survey has not been completed, a partial list of gold alloys is included. This list consists of the type A, soft, and type B, medium gold alloys on which tests have been finished and which have been found to comply with the requirements of A.D.A. Specification No. 5. On the completion of the survey, a full list, including the type C, hard, alloys, will be published, containing all those alloys which comply.

In purchasing certified materials for use in your practice, these lists should be used as a buyer's guide. In addition, the package of material received should be checked for its exact name as given in the lists, and for a statement guaranteeing compliance with the specification.

The last step is recommended, because there are several instances in which the manufacturer of a certified product also makes materials of the same kind that do not meet the requirements of the specification and are not certified. For example, "X" Green Wax-Medium may be on the list of certified waxes, but "X" Green-Soft and "X" Green-Hard do not meet the requirements of the specification.

Unless deliveries of such materials are carefully checked, one can easily accept the wrong material.

CERTIFIED AMALGAM ALLOYS (A.D.A. SPECIFICATION NO. 1.)

Alloy	Manufacturer and Distributor
Accurate Metalloy (filings)	The L. D. Caulk Co.
Ackerman (filings)	Ackerman Dental Mfg. Co.
Argentum ("A" cut)	Hammond Dental Mfg. Co.
Argentum (fine cut)	
Argentum (medium cut)	
Argentum (shavings)	
Aristaloy	Baker & Co., Inc.
Banner (filings)	Goldsmith Bros. S. & R. Co.
Blue Diamond (filings)	Reliance Dental Mfg. Co.
Brewster Medium (shavings); Quick (filings); Quick (shavings)	E. R. S. Brewster
Capeako (filings)	Precious Metals Refining Works
Certified	Lee S. Smith & Son Mfg. Co.
Coe	Coe Laboratories, Inc.
Cresilver	Crescent Dental Mfg. Co.

Dee (filings)	Thomas J. Dee & Co.
Dentserve	Dentists Supply Service
Diamond Edge	Young-Baker & Co.
Excel	Daniels Dental Alloy Co.
Fellowship, New	Dental Protective Supply Co.
Fleck's	Mizzy, Inc.
Garfield's	Garfield Smelting and Refining Co.
Gold Bond	Jefferson Laboratories
Lustraloy, Regular	A. Pfingst
Lustraloy Cut T	A. Pfingst
Minimax (filings) 173, 177, 178, 193, (shavings) 177, 178	The Minimax Co.
Minimax White Gold & Platinum	The Minimax Co.
Mission No. 5	Henry F. Bruce Co.
Mission No. 5 ("A" cut)	Henry F. Bruce Co.
Mission No. 6	Henry F. Bruce Co.
Modeloy (Quick Setting) (filings)	Crescent Dental Mfg. Co.
Moyco Higrade	The J. Bird Moyer Co.
Mynol Improved	Mynol Chemical Co.
New Deal	Miller Dental Co.
Ney-Aloy	The J. M. Ney Co.
Ney's No. 125	The J. M. Ney Co.
Odontographic "Improved" (filings)	Odontographic Mfg. Co.
Pearlol	Wildberg Bros. S. & R. Co.
Preferred C	Precious Metals Refining Works
Preferred D	Precious Metals Refining Works
Research Oralloy	Precious Metals Research Work, Inc.
Royal Special—First Setting	Garhart Dental Specialty Co.
Royal Super—First Setting	Garhart Dental Specialty Co.
Silver Crown	General Refineries, Inc.
Silver Crown (medium)	General Refineries, Inc.
Silverloy (filings), Silverloy (shavings)	Crescent Dental Mfg. Co.
Speyer	Speyer Smelting & Refining Co.
S-C Medium (filings); S-C Quick (filings)	Stratford-Cookson Co.
S-R	Lee S. Smith and Son Mfg. Co.
Standard	Standard Dental Products Co.
True Dentalloy (filings)	The S. S. White Dental Mfg. Co.
True Dentalloy (cut "A")	The S. S. White Dental Mfg. Co.
Twentieth Century (regular)	The L. D. Caulk Co.
Twentieth Century (special)	The L. D. Caulk Co.
Uniform	Henry Nelms & Son
Vertex	Vertex Dental Products Co.
White Beauty	Lang Dental Mfg. Co.

CERTIFIED INLAY CASTING INVESTMENTS (A.D.A. SPECIFICATION No. 2.)

Investment	Manufacturer or Distributor
Coecal Inlay	Coe Laboratories, Inc.
Coecal Universal	Coe Laboratories, Inc.
Kerr Cristobalite-Inlay	Kerr Dental Mfg. Co.
Ransom and Randolph Gray	The Ransom & Randolph Co.
Ransom and Randolph Green	The Ransom & Randolph Co.
S. S. White Inlay No. 20	The S. S. White Dental Mfg. Co.
Security Improved Inlay	The Cleveland Dental Mfg. Co.
Steele's-Super	The Columbus Dental Mfg. Co.

CERTIFIED IMPRESSION COMPOUNDS (A.D.A. SPECIFICATION No. 3.)

Compound	Type	Manufacturer or Distributor
Certified	I	Lee S. Smith & Son Mfg. Co.
Kerr Perfection	I	Kerr Dental Mfg. Co.
Kerr No. 2 Soft Green	I	Kerr Dental Mfg. Co.

Mizzy—Low Heat	I	Mizzy, Inc.
Moyco Special	I	The J. Bird Moyer Co.
S. S. White—Black—Tray	II	The S. S. White Dental Mfg. Co.

CERTIFIED INLAY CASTING WAXES (A.D.A. SPECIFICATION No. 4.)

Wax	Manufacturer or Distributor
Caulk-Blue	The L. D. Caulk Company
Kerr-Blue—Hard	Kerr Dental Mfg. Co.
Maves Green	The Heidbrink Co.
Security	The Cleveland Dental Mfg. Co.
Sterling	Baker & Co., Inc.
Taggart's Green	Mizzy, Inc.

PARTIAL LIST OF CERTIFIED INLAY CASTING GOLD ALLOYS (A.D.A. SPECIFICATION No. 5.)*

Alloy Type A, Soft	Manufacturer or Distributor
Aderer-A-Soft	Julius Aderer, Inc.
Baker Inlay Soft	Baker & Co., Inc.
Bruce "A"	Henry F. Bruce Co.
Bruce No. 1	Henry F. Bruce Co.
Chilcast No. 1	Vernon-Benshoff Co.
Crown Inlay No. 2 Soft	General Refineries, Inc.
Crown K	General Refineries, Inc.
Deeone	Thomas J. Dee and Co.
Goldsmith Inlay No. 1	Goldsmith Bros. S. & R. Co.
Jelenko Special Inlay	J. F. Jelenko & Co., Inc.
Krause Soft Inlay	Krause Gold Refinery
Research-A-Soft	Precious Metals Research Works, Inc.
Spyco Soft	Spyco Smelting & Refining Co.
S. S. White No. 2	The S. S. White Dental Mfg. Co.
S. S. White No. 900	The S. S. White Dental Mfg. Co.
S. S. White No. 940	The S. S. White Dental Mfg. Co.
Stern No. 3375	I. Stern & Co.
Williams No. 3	The Williams Gold Refining Co., Inc.
Williams Will-Cast 22	The Williams Gold Refining Co., Inc.

Alloy Type B, Medium	Manufacturer or Distributor
Aderer-B-Medium	Julius Aderer, Inc.
Baker Inlay Medium	Baker and Co., Inc.
Bruce "O"	Henry F. Bruce Co.
Bruce No. 2	Henry F. Bruce Co.
Chilcast No. 1-A	Vernon-Benshoff Co.
Chilcast No. 2	Vernon-Benshoff Co.
Chilcast No. 2-A	Vernon-Benshoff Co.
Crown Inlay No. 1 Hard	General Refineries, Inc.
Crown Knapp No. 2	General Refineries, Inc.
Crown T	General Refineries, Inc.
Goldsmith Inlay No. 2 Medium	Goldsmith Bros. S. & R. Co.
Jelenko Modulay	J. F. Jelenko & Co., Inc.
Jelenko Platincast	J. F. Jelenko & Co., Inc.
Krause Hard Inlay	Krause Gold Refinery
Nelms E	Henry Nelms & Son
Ney-Oro A-1	The J. M. Ney Co.
Ney-Oro A-10	The J. M. Ney Co.
Spyco Medium	Spyco Smelting & Refining Co.
S. S. White No. 1	The S. S. White Dental Mfg. Co.
S. S. White No. 5	The S. S. White Dental Mfg. Co.
S. S. White No. 820	The S. S. White Dental Mfg. Co.

*Survey now in progress (see introduction)

Stern No. 3290	I. Stern & Co.
Stern No. 6219	
Tinker No. 1	Spyco Smelting & Refining Co.
Wildberg "A"	Wildberg Bros. S. & R. Co.
Williams Pioneer	The Williams Gold Refining Co.
Williams Special Inlay	

CERTIFIED DENTAL MERCURIES (A.D.A. SPECIFICATION No. 6.)

Mercury	Manufacturer or Distributor
Argentum	Hammond Dental Mfg. Co.
Chemically Pure	The S. S. White Dental Mfg. Co.
Crown	General Refineries, Inc.
Dee	Thomas J. Dee & Co.
Dental	Goldsmith Bros. S. & R. Co.
Excel	Daniels Dental Alloy Co.
Fellowship	Dental Protective Supply Co.
Garfield's	Garfield S. & R. Co.
Garhart's Positively Pure	Garhart Dental Specialty Co.
Krause's Pure	Krause Gold Refineries
Mercury Laboratories	Mercury Laboratories, Inc.
Minimax	The Minimax Co.
Mission	Henry F. Bruce Co.
Moyco	The J. Bird Moyer Co.
Mynol	Mynol Chemical Co.
Ney's C. P.	The J. M. Ney Co.
Odontographic	Odontographic Mfg. Co.
Research	Precious Metals Research Works, Inc.
R. P. C.	Research Products Corporation
Spectropure	Baker & Co., Inc.
Twentieth Century	The L. D. Caulk Co.
Williams	The Williams Gold Refineries Co., Inc. (Applies to Williams' one pound bottles only, as quarter pound containers are not glass.)

CERTIFIED WROUGHT GOLD WIRE ALLOYS (A.D.A. SPECIFICATION No. 7.)

Alloy	Manufacturer or Distributor
Aderer No. 1	Julius Aderer, Inc.
Aderer No. 3	
Aderer No. 4	
Aderer No. 20 Clasp	
Baker 21	Baker & Co., Inc.
Baker Q. A.	
Crown Hylastic	General Refineries, Inc.
Deepep-Hard	Thomas J. Dee & Co.
High Fusing Clasp	Goldsmith Bros. S. & R. Co.
Jelenko No. 3 Wire	J. F. Jelenko & Co., Inc.
Jelenko Super Wire	
Medium Clasp	Goldsmith Bros. S. & R. Co.
Ney-Oro Elastic No. 4	The J. M. Ney Co.
Neydium 9	
Regular Clasp	Goldsmith Bros. S. & R. Co.
Spyco No. 2	Spyco Smelting and Refining Co.
Spyco No. 4	
Stern No. 2657	I. Stern and Co., Inc.
S. S. White No. 12	The S. S. White Dental Mfg. Co.
S. S. White No. 61 Metalba	
Williams No. 1 Super	The Williams Gold Refining Co.
Williams No. 2 High Fusing Clasp	
Williams No. 3 High Tensile	

CERTIFIED ZINC PHOSPHATE CEMENTS (A.D.A. SPECIFICATION No. 8, First Revision)

Cement	Manufacturer or Distributor
Ames Z-M	The W. V-B Ames Co.
Bosworth's Zinc	Harry J. Bosworth Co.
Caulk Crown and Bridge	The L. D. Caulk Co.
Caulk Petroid Improved	
Caulk Tenacin	
Certicem	Lee S. Smith and Son Mfg. Co.
Fleck's Extraordinary	Mizzy, Inc.
Lang Dental Crown Bridge and Inlay	Lang Dental Mfg. Co.
Moyco Adamant	The J. Bird Moyer Co., Inc.
Moyco Inlay Crown and Bridge	
Moyco White Copper	
S-C	Stratford-Cookson Co.
Smith's	Lee S. Smith and Son Mfg. Co.
S. S. White Silver "A"	The S. S. White Dental Mfg. Co.
S. S. White Silver "B"	
S. S. White Silver Improved	
S. S. White Zinc	
S. S. White Zinc, Improved	

CERTIFIED SILICATE CEMENTS (A.D.A. SPECIFICATION No. 9.)

Cement	Manufacturer or Distributor
Ames Plastic Porcelain	The W. V-B Ames Co.
Astralit	Premier Dental Products Co.
Baker Plastic Porcelain	Baker & Co., Inc.
DeTrey's Synthetic Porcelain	The L. D. Caulk Co.
Durodent Enamel	Oskar Schaefer
Smith's Certified Enamel, Improved	Lee S. Smith & Son Mfg. Co.
S. S. White Filling Porcelain, Improved	The S. S. White Dental Mfg. Co.

CERTIFIED HYDROCOLLOIDAL IMPRESSION MATERIALS (A.D.A. SPECIFICATION No. 11)

Material	Manufacturer or Distributor
Deelastic	Thos. J. Dee and Co.
Dentocoll	The L. D. Caulk Co.
Kerr Hydro-Colloid	Kerr Dental Mfg. Co.
Perfectocoll	Baker & Co., Inc.
Plasticoll	Lee S. Smith & Son Mfg. Co.
S. S. White Elastic Colloid	The S. S. White Dental Mfg. Co.
Surgident	Surgident, Ltd.

CERTIFIED DENTURE RESINS (A.D.A. SPECIFICATION No. 12.)

Material	Form	Certified by
Acralite	Clear, powder-liquid	Acralite Co., Inc.
Acralite	Pink, powder-liquid	
B-B	Clear, powder-liquid	Bell Dental Products Co.
B-B	Pink, powder-liquid	
Coralite	Pink, powder-liquid	Coralite Dental Products Co.
Densene	Clear, powder-liquid	Cosmos Dental Products, Inc.
Densene	Pink, powder-liquid	
King's	Pink, powder-liquid	Alfred T. King
Lucitone	Clear, plastic cake	The L. D. Caulk Co.
Lucitone	Clear, powder-liquid	
Lucitone	Pink, plastic cake	
Lucitone	Pink, powder-liquid	

Luxene 44	Pink, plastic cake	Luxene, Inc.
Marvel	Pink, powder-liquid	Marvel Dental Products Co.
Stryker's	Pink, powder-liquid	Stryker's Dental Products, Inc.
Vernonite	Clear, plastic cake	Vernon-Benshoff Co.
Vernonite	Pink, plastic cake	
Vernonite	Pink, powder-liquid	
Vita-Lite	Clear, powder-liquid	Vita-Lite Products Co.
Vita-Lite	Pink, powder-liquid	

COUNCIL ON DENTAL EDUCATION

TEXAS DENTAL COLLEGE JOINS UNIVERSITY OF TEXAS

THE dental educators of the entire country and particularly the dental profession of the Southwest will be gratified to know that the regents of the University of Texas have agreed to take over the Texas Dental College and to operate it as a unit of a great state medical center to be developed by the university at Houston. Homer P. Rainey, president of the university, in making public announcement of the plans, revealed that a 134-acre site for the new medical center will be provided by the M. D. Anderson Foundation of Houston and that the foundation will furnish the funds for the erection of a building to house the dental unit. Actual building operations may have to wait until after the war. An agreement has already been reached between the present trustees of the college and the university authorities, subject to final authorization by the legislature.

The Texas Dental College was founded in 1905 by a group of business and professional men in Houston and was reorganized as a public trust in 1929. The movement to have the college taken over by the University has been led by Frederick C. Elliott, who has been dean of the college for the past twelve years.

This entry of the University of Texas into the field of dental education is in line with the aims of the Council on Dental Education and leaves only five of the thirty-nine dental schools in the United States not an integral part of a well recognized university.

Two of the five are associated with important medical centers and only three are wholly detached independent institutions. The Council hopes in the near future to see all dental education under the ownership and control of universities.

COMMITTEE ON LEGISLATION

DISSATISFACTION WITH DENTAL SERVICES AS GROUNDS FOR REFUSING PAYMENT

By LESLIE CHILDS, Indianapolis, Ind.

THE right of a patient to refuse payment for dental services on the grounds of dissatisfaction has been the subject of considerable litigation. The subject may be divided as follows: (1) cases in which the dentist expressly agrees to perform to the satisfaction of the patient and (2) cases in which there is only the implied agreement to perform in accordance with the recognized standard of practice.

In the first class of cases, the patient will usually be the judge of his satisfaction; and, if he is dissatisfied, in good faith, this may be sufficient to justify his refusal to pay. In the second class, mere dissatisfaction may fall short of a defense against payment, and, in addition, the burden will be upon the patient to show cause for his dissatisfaction that applies to the quality of the services.

The application of these rules may be illustrated by reviews of cases from each class. And, as an example of judicial reasoning in a case of the first class, i.e. wherein the dentist has expressly warranted satisfaction, Aymar *vs.* Bloomingdale *et al.*, 157 N.Y.S. 837, is here cited.

SATISFACTION WARRANTED

In this case, the defendants, dentists, undertook to render professional service, mainly bridge and crown work, to the plaintiff. Under the contract of employment, the defendants expressly agreed that if the plaintiff was not satisfied with the work, the money paid therefor would be returned.

Upon completion of the work, the plaintiff paid the defendants in full. Thereafter, the plaintiff brought the instant action for the return of his money on the grounds of his dissatisfaction with the work. In support of his claim, the plaintiff testified that "after the work was performed it pained him continuously for six months, and he then went to another dentist and had the work . . . removed."

In defense, the defendants, while admitting the agreement to refund the price of the work if the plaintiff was dissatisfied, took the position that the plaintiff's evidence that his dissatisfaction was real and not assumed was insufficient. The defendants received a judgment in the trial court, but the higher court, in reviewing the record and in reversing the judgment, reasoned:

> The defendants do not contend that they are not bound to return the money paid if the plaintiff is personally dissatisfied, but they contend that the plaintiff has not shown that his dissatisfaction was real and not assumed. It seems to me that it is impossible to show dissatisfaction more unequivocally than by proof that, after dental work is performed by one dentist, the patient has submitted himself to the tender mercies of a second dentist and had the original work removed. The judgment should be reversed . . . and judgment ordered for the plaintiff.

In another case of this kind, Davis *vs.* Ball *et al.*, 60 Mass. (6 Cush) 505, 53 Am. Dec. 53, an early case, by the way, dated 1850, the defendants, who were dentists, issued a receipt and warranty for services rendered which, in part, said:

> To operations in dentistry, Aug. 20: In-

serting one upper set and part of lower set of teeth on gold plate, warranted for one year; and if on trial they cannot be made useful, the teeth to be returned and the money refunded when called. Received payment, $110.

WARRANTY HELD BINDING

Within the year, the plaintiff returned the teeth and demanded the return of the money paid, on the grounds that they were not "useful" to his wife, for whom the teeth had been made. In upholding the plaintiff's claim, the court said:

The writing is the best evidence of the contract ultimately concluded between the parties. . . . The teeth were made, completed, finished. Though ever so skilfully made, it was uncertain . . . whether the person for whose use they were designed would be able to use them. It was therefore agreed that if the plaintiff's wife, upon trying them, should find that she could not use them or make them useful, she might return them, and the money would be refunded."

So much for the so-called "satisfaction or money back" class of contracts. And now let us turn to the second division; i.e., cases in which the dentist merely performs under an implied agreement that workmanship and materials will meet the recognized standards of his locality. Holsapple *vs.* Scofield, 176 Wis. 649, 187 N.W. 682, will serve to illustrate.

The plaintiff, a dentist, after the necessary extractions, made a set of upper and lower dentures for the defendant. After several readjustments, the defendant expressed her dissatisfaction with the dentures, and after wearing them about four days, returned them and declined to pay the balance due on the account. The plaintiff filed suit.

Upon trial the plaintiff established by expert testimony that the workmanship and materials were good and that the price charged was reasonable. The defendant offered no testimony on this point, but rested her case on evidence that the teeth did not fit properly, and that while she used them, the lower denture caused her pain and soreness.

From judgment in favor of the defendant, the plaintiff appealed, and the higher court in reviewing the record and in directing judgment for the plaintiff, said in part:

If the plaintiff performed the dental services for the defendant and did the same in a good workmanlike manner in accordance with the recognized and established practice of those in the same profession in his locality, he became entitled to the reasonable value of his services.

We must hold in this case that the issue here presented was one upon which expert rather than lay evidence was necessary. . . . The testimony of those familiar with that kind of work and services was all one way and to the effect that it was in accordance with the recognized standard of skill in that locality.

It is uncontradicted that a satisfactory result could not in the nature of things be expected during the short time in which the defendant attempted to try the teeth furnished by the plaintiff, and she herself testifies that she refused to continue any further. . . . It follows that the court should have set aside the verdict and granted the plaintiff's motion for the amount asked for in the complaint. Judgment reversed . . . with directions to render judgment for the plaintiff.

So, as illustrated in the foregoing case, mere dissatisfaction with dental services does not constitute a defense to payment, and certainly, even granting the dissatisfaction to be real, the dentist is entitled to the cooperation of his patient in removing the cause of the dissatisfaction.

Of course, the extent to which the dentist may be entitled to go in correcting work will depend greatly upon the character of the services. Naturally, he will be accorded greater liberty in correcting dentures or other inanimate restorations than in replacing crowns or doing other work which subjects the patient to pain and discomfort. This point

is illustrated in an interesting manner in Berger *vs.* Rifkin, 179 Atl. 3.

JACKETS OFF COLOR

The plaintiff, a dentist, sued for a balance of $425 alleged to be due for dental services rendered principally to the defendant's wife. The original claim, it appears, was for $1,025, but it had been reduced as indicated above by payments.

A large part of the work consisted in fitting porcelain jackets, and payment was resisted on the ground that in color these did not match the patient's natural teeth. The plaintiff offered to replace the jackets, and when this offer was refused, the suit followed. The defendant had a verdict in the trial court, and, in approving it, the higher court reasoned, in part, as follows:

> The evidence relating to the manner in which the plaintiff had done his work and the results thereof being conflicting, a clear issue of fact was raised. . . . It is evident from the verdict that the jury was satisfied that the plaintiff had been reasonably paid for his services. . . .
>
> We are also of the opinion that, under the circumstances of this case, the plaintiff can claim no advantage by reason of the fact that he offered to replace the jackets in question. Very possibly, in certain instances, when work has been improperly performed, an offer to do it over, if seasonably made, may receive consideration. In many cases, such work is done upon chattels or other inanimate objects.
>
> In the instant case, however, the services were performed upon a human being, and, from their nature, a considerable amount of pain, discomfort and inconvenience were incident thereto. If the plaintiff's suggestion were followed and new jackets put on, it would necessitate the removal of the old jackets, which are now cemented to the natural teeth of the defendant's wife, and the fitting and cementing of new jackets, all of which undoubtedly would cause the patient further pain and discomfort.
>
> We find that the defendant's wife was not required to submit herself a second time to the plaintiff, so that he might make new jackets. . . . The case is remitted to the superior court for the entry of judgment on the verdict.

SUMMARY

From the foregoing, there is clearly a well-defined distinction between "satisfaction" and implied contracts covering dental services. In the former, the dissatisfaction of the patient constitutes the measure of any dispute arising thereunder. Further, expert testimony is not essential in proving a case, and unless the dentist can show that the dissatisfaction is unreasonable or assumed, his liability to refund or waive payment may be enforced.

In the second class of contracts, implied, when the dentist has shown that his work accorded with the recognized standard in his locality, he will have established his case. And here, where the grounds of a patient's dissatisfaction call for professional judgment in respect to their existence, expert evidence will be required and controlling.

However, where dissatisfaction is grounded upon defects which are obvious to laymen, expert evidence may not be essential to their establishment. And, as is illustrated in the last case reviewed herein, a question of fact will usually be raised upon which the verdict of a jury will, in the majority of cases, be conclusive.

REPORT OF INSURANCE COMMITTEE

August 23, 1942

To the House of Delegates and the Board of Trustees of the American Dental Association:

Your Insurance Committee is pleased to report that the American Dental Association group life insurance program has reached a new high of more than 9,000 members, insured for more than $23,000,000 of insurance.

We are also pleased to be able to inform you that the mortality experience during the past policy years was the lowest in the entire history of the coverage, and that, as a consequence, our group has a higher health rating than ever before.

Your committee, together with representatives of the Great West Life Assurance Company, has carefully considered the question of increased benefits under the present plan, at no increase in cost. In view of the situation brought about by the War, it is impossible to estimate the future increase in mortality. We feel it would be unwise, therefore, to extend benefits at this time, which might possibly have to be discontinued. This is in accordance with the Insurance Committee's desire to keep the stability of the plan its first consideration. Your committee is in close contact with the company, and is pleased to assure you, and those insured, that as soon as conditions are normal, increased benefits will be forthcoming.

Arrangements have been made whereby the insurance of members in occupied territory (such as Guam and Midway) will be kept in force. In other words, any member who is unable to pay his premium because of enemy action will still enjoy the benefits of the American Dental Association group life insurance and, in event of death, his beneficiary will receive the full amount of his policy, less the unpaid premiums.

We would like to take this opportunity of bringing to your attention the following facts:

1. All members who were insured under the American Dental Association group life insurance plan prior to April 15, 1942, are insured against death from any cause (except suicide and unlicensed aviation, during the first two years), whether at home or in any theater of war.

2. All members insured since April 15, 1942, are insured against death from any cause, except as above stated, while within the boundaries of the United States, Canada, Alaska and Newfoundland.

I would like to add that the restrictions have been fully explained and that the new business received since the clause became operative has not slowed progress. Approximately $1,500,000 of new business has been issued with war restrictions since April 15, 1942.

More than $2,500,000 has been paid in death claims and not one contested claim is pending.

All in all, in spite of the unsettled condition, your committee feels that the group insurance program has never been in a better financial condition than at present.

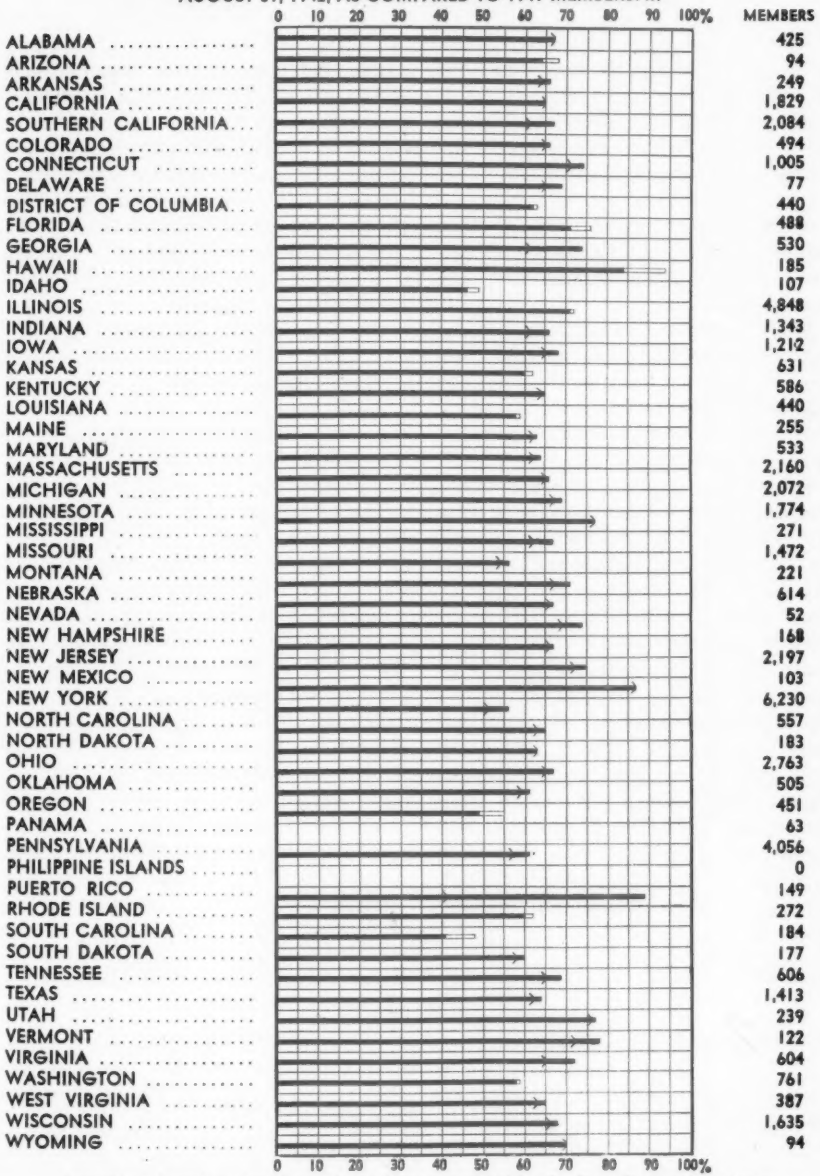
Respectfully submitted,

A. D. WEAKLEY, *Chairman.*

FRED H. RICH, *Secretary.*

Membership Page

PERCENTAGE OF DUES RECEIVED IN CENTRAL OFFICE AS OF AUGUST 31, 1942, AS COMPARED TO 1941 MEMBERSHIP



Percentage based on dental population figures supplied by the State Society Secretaries.

1942 percentage. 1941 percentage.

NEWS ITEMS

NORTHERN OHIO DENTAL ASSOCIATION TO DISBAND

A SPECIAL meeting has been called for Monday, December 7, 1942, at 4 o'clock, in the Hotel Statler, Cleveland, Ohio, to which all former members of the Northern Ohio Dental Association are invited.

At this meeting, the Executive Council will recommend disbanding and the membership will vote upon plans of liquidation.

This pioneer organization was founded in Cleveland, Ohio, November 3, 1857, by thirty-six members. It originated in response to a resolution of the American Dental Convention in 1855, recommending the organization of local societies. It is one of the oldest organizations in the country, being in its eighty-fifth year. With few exceptions, meetings were held regularly each year, usually in the City of Cleveland. Since 1935, no general scientific sessions have been held, but the executive council has held meetings annually, pending future developments as to the advisability of continuing as a supplementary branch of organized dentistry or disbanding. While it was originally the component of the American Dental Association in Northern Ohio, the present Ohio and neighboring state components, together with their local components, have absorbed the membership of the Northern Ohio Dental Association into their organizations.

The official minutes of this association are replete with the names of pioneers in dentistry, not only in the territory known as the Western Reserve, but also nationally, many of whom are now very active in their respective communities. The three-day scientific sessions were always well attended and served as a pattern for future dental meetings.

By Order of the Executive Council
J. C. MCCONKEY, *President,*
701 Renkert Bldg.,
Canton.
C. J. STARK, *President-Elect,*
1034 B. F. Keith Bldg.,
Cleveland.
D. D. SMITH, *Secretary,*
1309 Market St.,
Sandusky.
A. DALTON GILL, *Treasurer,*
751 West Central Ave.,
Toledo.
C. R. A. HOFFMAN,
6503 Detroit Ave.,
Cleveland.
C. H. LOUGHRY,
2020 Tower Bldg.,
Akron.
GEORGE L. DRACH, JR.,
1808 Medical Arts Bldg.,
Cleveland.

AN INSTITUTE OF WAR MEDICINE AND SURGERY FOR DENTISTS

AN intensive four-day institute of war medicine and surgery for dentists is to be offered to all members of the American Dental Association, under the sponsorship of the Chicago Dental Society, October 26-29.

The lectures will be held in the John B. Murphy Memorial Hall of the American College of Surgeons, 50 East Erie St., Chicago. Registration and tuition fee, $20.

Subjects:

1. Traumatic surgery: Two lectures which will cover the following: (a) the

treatment of shock and hemorrhage; (b) the use of splints; (c) the treatment of burns; (d) the use of blood plasma; (e) the use of the sulfonamide drugs; (f) such other subjects of a surgical nature as are encountered under conditions of warfare.

2. Tropical medicine: Two lectures to acquaint dentists with the tropical diseases that they may encounter on the global battlefronts, with the oral manifestations of such diseases and such other aspects of disease as come under the wide scope of tropical medicine.

3. Military sanitation: Two lectures. In combat, a dental officer is often entrusted with the duties of a sanitation officer. He is in charge of the protection of water supply, the disposal of sewage and the handling of foodstuffs.

4. Aviation medicine: Two lectures. This new problem in medical science offers wide possibilities for study and investigation. There are certain definite dental implications in aviation medicine. For example, partial stenosis of the eustachian tube caused by overclosure of the mandible makes the equalization of external and internal pressure difficult during rapid aerial descent. It has been found that many fliers, particularly dive bombers, need the vertical dimension increased and the condylar head repositioned to prevent the syndrome of dizziness, ringing in the ears and stuffiness, which frequently follow rapid descent.

5. Military psychiatry: Two lectures. It is known that when large groups of people are gathered together either as combatants or as civilian victims of warfare, certain neuroses are likely to develop. The dental officer should be prepared to meet these behavior problems among the people that he may have to treat.

6. Nutrition in wartime: Two lectures. The use of dehydrated and concentrated food has nutritional and dental importance. It is likewise important that the dentist know something about the nutritional conditions and the possible deficiency diseases that confront troops in the widespread territories of present warfare.

7. Prosthetic services in war: Three lectures on the general subject of prosthetic services in war, including (a) construction of splints for the use of fracture reduction and immobilization; (b) prosthetic facial restorations of the nose, ear and other parts; (c) construction of aviation splints, the basic subject of which was mentioned and will be covered under aviation medicine.

8. Oral surgery in war: Three lectures on the general subject, including (a) local anesthesia under war conditions; (b) general anesthesia under war conditions; (c) fundamental technic in plastic and maxillofacial surgery.

In addition to these eighteen lectures, there will be six lectures covering military background information, and three evening sessions devoted to subjects of interest to dentists during war.

The following military officers will act as advisors:

Col. Arnett P. Matthews, Chief Dental Officer of the Sixth Service Command.

Capt. J. A. Tartre, Senior Dental Officer of the Ninth Naval District.

Please enter my name in the enrollment for the proposed Institute of War Medicine and Surgery for Dentists under the auspices of the Chicago Dental Society. My check for $20 in payment of the registration and tuition fee is enclosed.

Name .....

Address .....

Make checks payable to The Chicago Dental Society and mail to 30 North Michigan Ave., Chicago, the office of the society.

Maj. Kenneth R. Cofield, Liaison Officer between the Office of the Surgeon General and the American Dental Association.

Com. Fred F. Molt, Dental Corps, United States Navy.

All lecturers will be persons of preeminence in their fields. Their names will be published in an early issue of the *Fortnightly Review of the Chicago Dental Society.*

A suitable certificate will be issued to all persons who complete the course, with attendance at all sessions.

The Chicago Dental Society Commission for the Aid of Needy Members will receive any profit from this course.

A registration blank is provided herewith.

Inasmuch as 100 of the 700 seats available are reserved for dental officers of the Army and Navy, dentists who are interested in attending the Institute of War Medicine and Surgery are urged to register at once. A registration admittance card will be sent to registrants.

THE ORAL SURGERY JOURNAL

In response to the questionnaire sent out by the Board of Trustees in reference to the publication of an oral surgery journal, a sufficient amount of interest was evidenced to warrant its publication. Accordingly, the recommendation of the Board of Trustees to publish *The Journal of Oral Surgery* was approved by the House of Delegates at St. Louis.

AMERICAN DENTAL ASSOCIATION

FUTURE ANNUAL MEETINGS

In order to continue the business of the American Dental Association, it is recommended that the Board of Trustees, House of Delegates and committees shall meet annually in a centrally located city, as was done this year.

To meet the remote possibility that a transportation problem will develop, which will preclude the meeting of the House of Delegates, the following proposals are made:

(a) The provision in the By-Laws which states that an annual meeting shall be held each year shall be suspended.

(b) The provision in the By-Laws which states that standing committees shall make an annual report to the House of Delegates shall be suspended and those committees shall be instructed to report to the Board of Trustees in the interim.

(c) The budgetary arrangement adopted at this meeting shall be continued until the next meeting of the House of Delegates.

SECTION PAPERS INTENDED FOR THE BOSTON MEETING

The Board of Trustees suggested to the House of Delegates that section papers as listed in the preliminary program for presentation at the cancelled Boston meeting be approved by the House of Delegates for submission to the Editorial Department for publication. All such papers should be sent to the chairmen of the respective sections.

OBITUARIES

WALTER F. BARRY, SR., D.D.S.

1878-1942

DIED July 5, 1942, Walter F. Barry, Sr., of Newark, N. J.

Dr. Barry was born in Orange, N. J., the son of Michael and Mary McHugh Barry. He received his early education at Seton Hall Academy, Orange, and was graduated from Pennsylvania University School of Dentistry in 1906. He became internationally known as an oral surgeon, exhibiting early a talent for surgery. He was appointed as assistant to the late Prof. Matthew H. Cryer while in his senior year at the dental school. After interning for two years at the Philadelphia Hospital, he began the general practice of dentistry in Orange, N. J. In preparation for his entrance into oral surgery as a specialist, he studied with the late George B. Winter in St. Louis, with whom he established a lifelong friendship; the two being generally seen together at dental meetings here and abroad until the death of Dr. Winter.

It was for his skill in oral surgery that Dr. Barry first received international recognition, and he was sought as a lecturer and clinician here and abroad. Aside from his many appearances as clinician and essayist at state and national meetings, he lectured in Vienna, England, France and Spain. Last year, he gave a course in oral surgery in Havana, Cuba.

Walt Barry, as he was known to his associates, had been president of the New Jersey State Society; four times a member and twice president of the state dental board of New Jersey; a fellow of the American College of Dentists, and New York Academy of Dentistry; a member of the American Society of Oral Surgeons, and, at the time of his death, a member of the National Board of Dental Examiners and president of the National Association of Dental Examiners. For many years, he was associated with John A. Lukas in the practice of oral surgery in Newark. In March 1942, he was appointed dental director of the New Jersey State Hospital at Greystone Park, where he was in the midst of re-

WALTER T. BARRY, SR., D.D.S.
1878-1942

organizing the dental service when called by death.

Dr. Barry was beloved by his associates for his broadness of vision, goodfellowship and never tiring desire to help the other man, being always willing to impart to others the knowledge which he so richly possessed. Contributing abundantly to this life, he likewise received great joy from it and an ever-

present twinkle in his eye told the world that he enjoyed living.

While most of Dr. Barry's life was devoted to his profession, he found time to interest himself in his community life, where he took part in politics and social and welfare work. His chief hobby was golf, in which he excelled up to his last years, having won the New Jersey State senior championship in 1936.

His wife, Mrs. Ann Walsh Barry, three sons, Dr. Walter F. Barry, Jr., Ensign Frank Barry, Aviation Cadet James J. Barry, a daughter, Mrs. Nancy B. Rank, wife of Dr. John Rank, a brother, Dr. A. L. Barry, two sisters, Mrs. Genevieve Merrigan and Mrs. Henry O'Neill, and three grandchildren, survive.

Dentistry has lost a staunch member, but is fortunate in having had Walter Barry as one of its benefactors.

W. A. W.

WALTER SCHILKE, D.D.S.

1894-1942

ALTHOUGH called from our midst at the early age of 47, Walter Schilke had crowded into that short span a full lifetime of service, charity and good cheer.

As an outstanding practitioner of dentistry and a dental scientist, he contributed abundantly to the health and comfort of his fellowmen, not only through his skilful ministrations to his own patients, but also by his willingness and ability to teach others his methods and how to apply them. He loved his profession. He gave everything in him unselfishly to it, and his joy was reflected in the satisfaction of work well done.

Walter Schilke was possessed of abounding energy and enthusiasm and lived every minute of every day in contributing to many fields of endeavor. In addition to his professional interests, he builded his life in a happy family circle —his wife, a son, Albert Walter, aged 18, now attending Cornell predental college, a daughter, Lois Marguerite, 16, and a son Stuart A., 15, both attending high school in Englewood, N. J., a brother and two stepbrothers.

Dr. Schilke was a member and past president of the Englewood Rotary Club, a Mason, a Shriner and trustee of his church, the Englewood Methodist, and he was interested in community life in general.

A lover of nature and outdoor life, he sought relaxation and pleasure in his garden, in fishing, boating, golfing and bowling and as a "pal" to his wife and children.

WALTER SCHILKE, D.D.S.
1894-1942

His early life was spent at Matawan, N. J., where he obtained his early education in the public schools and at Perth Amboy High School.

Graduating from New York University College of Dentistry in 1916, he began practice in Englewood in 1917, after a year in the employ of Dr. Ernest Gluck

in New York City. He married Miss Lois Audrey Brown December 5, 1917.

Dr. Schilke had been a member of Bergen County Dental Society since 1919 and was its president in 1925. He was an alternate state society trustee 1939-1942; treasurer of the state society, 1935-1938; Delegate to the A. D. A. Annual Meetings, 1935-1940, and an Alternate for 1930-1934. He will be remembered by almost every dentist in the land for his clinics on the pinledge inlay, in which field he pioneered and in which he taught so many and so well during fifteen years. He was active in many dental health educational projects and other progressive dental endeavors, in which he was always willing to serve.

Walter Schilke's life was a full one and its benefits to humanity were great. We mourn his loss.

W. A. W.

DEATHS

CLANCY, HOWARD B., Chicago, Ill.; Northwestern University Dental School, 1932; died July 8.

ENGLISH, C. M., Sherman, Texas; St. Louis University School of Dentistry, 1902; died June 12; aged 65.

HEARNE, B. F., Fort Worth, Texas; Baylor University Dental School, 1910; died June 13.

KLINE, RAYMOND C., Cleveland, Ohio; died August 20.

KRAEMER, FREDERIC O., Brooklyn, N. Y.; New York College of Dentistry, 1883; died June 20.

LANE, EDGAR F., Chicago, Ill.; University of Illinois College of Dentistry, 1937; died March 28.

LAUTMAN, LOUIS J., Brooklyn, N. Y.; New York College of Dentistry, 1907; died April 20.

LONG, BENJAMIN A., Lima, Ohio; Ohio College of Dental Surgery, 1903; died May 20.

MCCOY, THOMAS R., Waterloo, Iowa; Northwestern University Dental School, 1901; died July 14; aged 60.

NASITS, BEN J., Tyler, Texas; School of Dentistry Tulane University, 1903; died May 22.

NEIL, LUTHER ALTON, El Paso, Texas; Chicago College of Dental Surgery, 1902; died June 17.

PAYNE, CHARLES B., Des Moines, Iowa; State University of Iowa College of Dentistry, 1906; died June 2; aged 61.

SALMON, MORTIMER R., Amityville, Long Island, N. Y.; New York University College of Dentistry, 1926; died May 20.

SHANE, JAMES W., Toronto, Ohio; Ohio College of Dental Surgery, 1890; died July 11.

SHARP, HARRY L., Maquoketa, Iowa; University of Nebraska College of Dentistry, 1916; died July 1; aged 61.

STRAITH, SAMUEL, Detroit, Mich.; Northwestern University School of Dentistry, 1897; died June 30.

TOMSUDEN, HENRY L., St. Petersburg, Fla.; School of Dentistry, University of Pennsylvania, 1918; died May 25.

UGLOW, STANLEY JOHN, Chicago, Ill.; Northwestern University Dental School, 1901; died August 2; aged 62.

INCIDENTS OF PRACTICE

Case of Tooth Fusion

By F. J. Loughlin,* D.D.S., Bangor, Maine

In the accompanying roentgenogram of the lower anterior teeth of a 13-year-old girl, the lower right central and lateral incisors appear to be fused. This is not the case. The patient has three other lower incisors in addition to this two-crowned lateral incisor with one root. The rest of the teeth in the mouth are of normal structure. The upper right second bicuspid is impacted in lingual version.

Two crowned lateral incisor with one root.

Station Hospital, Dow Field.
*Lieutenant, Dental Corps.

A Modification of the Hawley Retainer

By Walter H. Jacobs, D.D.S., New York, N. Y.

Very often, upon completion of orthodontic treatment, there is still need for an active force to prevent a relapse in the anterior segment of the arch, or even to continue slight movement of the upper anterior teeth lingually. A change in the design of the labial section of the Hawley retainer, as described below, will permit positive pressure against the anterior teeth if required.

Instead of the straight, flat section of wire which is used in the labial portion (Fig. 1), it is suggested that this part, from the mesial surface of one cuspid to the mesial surface of the opposite cuspid, be constructed of 0.028 resilient round wire with an open loop at the midline (Fig. 2). Resilient round wire, 0.028, can be easily adapted so that a tooth with a tendency to move out of alinement can, by slight adjustment of the open loop and the wire, be brought back to position. The open loop at the midline can be closed gradually, if desired, and, in this way, the

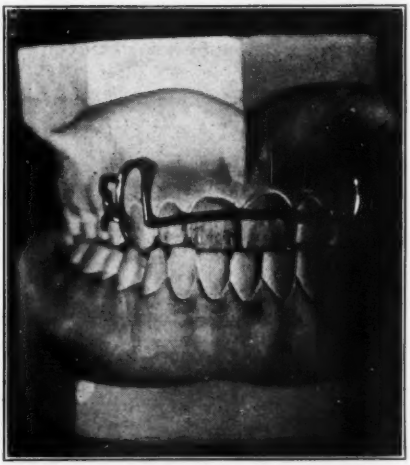


Fig. 1.—Hawley retainer (labial section).

Fig. 2.—Retainer substituted for Hawley appliance (Fig. 2).

anterior teeth will have a slight but constant pressure against them, with a tendency to move the teeth lingually.

It is important to make sure that the open loop does not interfere with the frenum. That part of the retainer directly in contact with the lingual surfaces of the anterior teeth should be relieved if the 0.028 wire is to be given a lingual adjustment.

124 West Ninety-Third Street.

Facial Harmony

By BERNARD D. LYNN, D.D.S., Detroit, Mich.

ONE of the most baffling problems of full denture prosthesis concerns the harmonious relationship of the restorative appliance to the rest of the face after completion of the dentures.

Even before the era of J. Leon Williams and Alfred Gysi, dentists tried in many ways to measure in precise numerical quantities certain relationships that would give a truely harmonious value to the patient, and ingloriously failed. However, if, instead of numerical quantities, certain easily ascertained values are sought, the resultant harmony greatly enhances the appearance.

All too often, we see the results of a discordant relationship in an astonishing, macabre appearance that causes the operator no little embarrassment.

It is the purpose of this paper to suggest a few simple methods by which the esthetic effects of the restoration can be enhanced.

THEORY

The old saying that we are "fearfully and wonderfully made" is truly evinced in studying the normal facial contours. Anatomic examinations reveal that there is a corresponding harmony of interrelated parts of the body. For our considerations, four measurements are important: from ala to ala of the nose during the inspiratory pause; from the angle of the eye (external canthus) to the angle of the mouth; from the base of the vertical septum of the nose (columella) to the vermilion border of the lower lip, and from the same position (columella) to the inferior border of the chin (symphysis mandibulae).

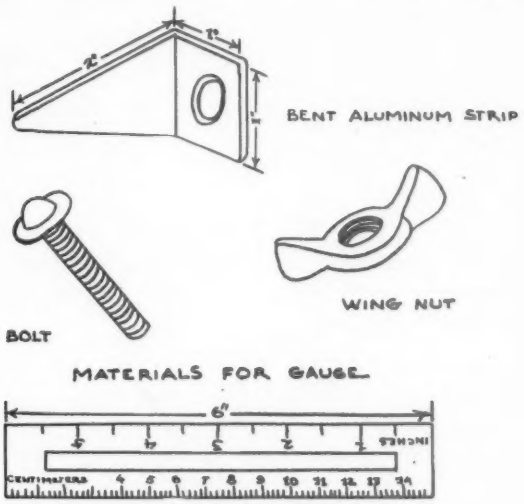


Figure 1.

The distance from ala to ala of the nose invariably determines the distance from the center of one cuspid tooth to the center of the cuspid tooth on the opposite side. Thus, with this measurement, a more harmonious width of the arch is assured.

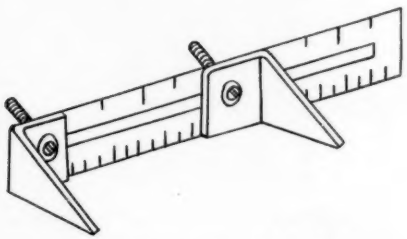
When the distance from the corner of the

mouth to the external canthus is equal to the distance from the columella to the lower border of the chin, the vertical relationship of the bite is in harmony. When these measurements are not equal, the bite is either opened or closed, the status depending on which distance is greater.

A third check on the harmonious final is the distance from the *ala nasi,* as compared to the distance from the base of the vertical septum of the nose, to the inferior border of the lower lip. These distances should be equal.

THE GAGE

To obtain the foregoing values, a gage is



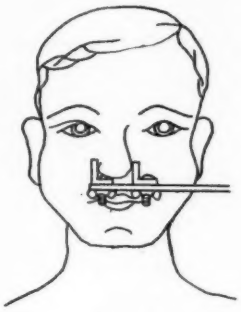
ASSEMBLED GAUGE

Figure 2.

discarded impression trays are perfect), and (3) bolts and wing nuts three-sixteenths inch size.

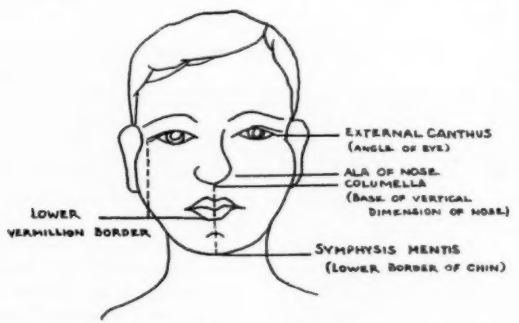
With knife-edge stones, a slot is made in the center of the ruler, as shown in the diagram. The width of the slot should be one-fourth inch, to barely permit insertion of the bolts. The slot should extend to within approximately one-half inch from each side.

Both aluminum strips are trimmed to size and tapered. Holes as indicated are drilled to permit passage of the bolts. Finally, each



FROM ALA TO ALA OF NOSE.

Figure 4.



REVIEW OF ANATOMICAL LANDMARKS

Figure 3.

of the utmost importance. The device herein described is extremely simple to make and to use. The cost is about 10 cents and the gage can be readily sterilized by any of the accepted methods.

The materials necessary are: (1) a 6-inch steel ruler; (2) aluminum strips (handles of strip is bent to a right angle at the point where the taper begins.

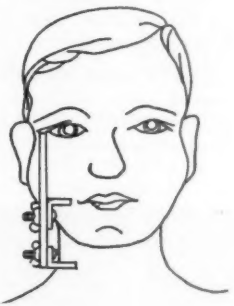
USE OF THE GAGE

Let us suppose that a patient, having been edentulous for some time, presents himself for denture service. The teeth were removed

by another dentist and no preextraction records exist. It is in such a case that the previously described gage is of great value.

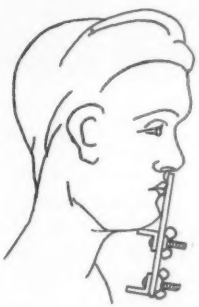
The impressions are taken and models and bite-blocks made according to the technic favored by the individual operator. At the next appointment, centric position is determined in the usual manner and the vertical dimension is also determined.

Step 1.—To establish the vertical dimension, the gage is first set up as indicated in



MEASURING FROM EYE TO ANGLE OF MOUTH

Figure 5.



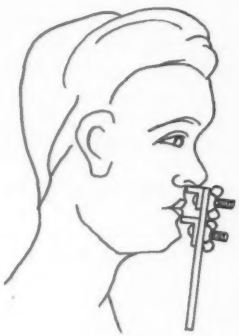
FROM COLUMELLA TO LOWER BORDER OF CHIN

Figure 6.

Figure 5, measuring from the angle of the eye to the angle of the mouth. This distance should coincide with the measurement obtained in Figure 7. When the measurements are equal, the vertical dimension is in harmony with the rest of the face.

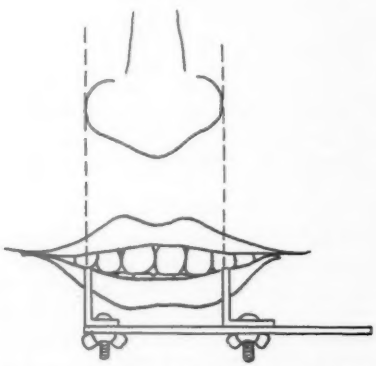
Step 2.—The relationship of the bite-blocks is secured in the customary manner—"keying," and "tacking" with a hot spatula or by any other convenient method.

Step 3.—The value obtained by measuring the interalar distance is used to establish the bulge of the lips. The amount of wax on the anterior of the bite-blocks is reduced or increased so that the value previously obtained (Fig. 4) is equal to the distance from the columella to the lower vermilion border. (Fig. 6.)



COLUMELLA TO LOWER VERMILLION BORDER

Figure 7.



CUSPID TO CUSPID EQUALS ALA TO ALA

Figure 8.

Step 4.—The line at the parting of the lips is marked to establish the occlusal plane. Next, the midline on the bite-blocks is marked. This is usually done by following the maxillary labial frenum downward with a knife.

Step 5.—The last step is to bisect the midline just obtained, with the interalar distance

along the line establishing the occlusal plane. (Fig. 8.)

THE SET-UP

The typal form of the tooth is obtained in any manner to which the operator is accustomed. The most efficient guide yet encountered is the Wavrin mold guide.

When the casts have been mounted on the articulator, the maxillary cuspid teeth are set up with the incisal tips on the markings as determined in Step 5. The body of each tooth must be set flush with the wax or the purpose of step 3 will be defeated. The remaining anterior teeth are set up and then the posterior.

The dentures are now ready to be tried in the mouth.

MEASUREMENTS

A total of 1,481 white people of both sexes were measured. The age ranged from 17 to 54 years. All of the subjects had most of their own natural teeth. All cases of gross malocclusion were eliminated from the examination. These people represented a typical cross-section of the average dental practice. The distance from ala to ala compared to that from cuspid to cuspid in 1,339 cases (90.4 per cent); from ala to ala compared to that from columella to lower vermilion border in 1,287 cases (86.9 per cent); from the angle of the eye to the angle of the mouth compared to that from columella to lower border of the chin in 1,432 (96.1).

CONCLUSIONS

The two important phases of prosthodontia concern function and esthetics. Any device or method which enhances either must be regarded as an aid in securing a denture that is pleasing in appearance as well as functionally acceptable.

The gage is not intended as a panacea for all esthetic evils in full denture prosthesis. It is to be regarded solely as an aid in establishing certain proportionate values that are a guide to the prosthodontist.

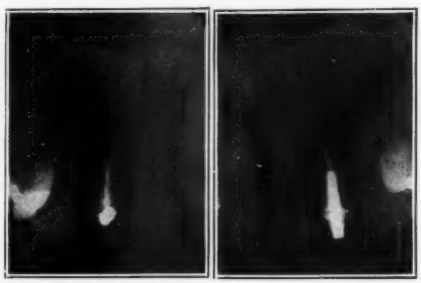
The individual operator should use these measurements as a basis of departure in restoring the facial harmony, so that the final result will be pleasant, and will gratify both the operator and the patient.

2900 South Fort Street.

Deposition of Bone Following Apicoectomy

By WILLIAM H. HOFFMAN, D.M.D., West Brentwood, Long Island, N. Y.

THE accompanying roentgenograms are of interest in demonstrating the action of the body in depositing bone, under functional stress, around amputated ends of teeth following apicoectomy.



Left. Right.

Deposition of bone following apicoectomy; after fourteen years.

The films were taken during a check-up of the upper right and left lateral incisors upon which an apicoectomy had been performed fourteen years previously by the patient's former dentist.

A lamina dura has been formed around the amputated root ends of both teeth. Trabeculae are discernible extending from the lamina dura into the surrounding bone tissue.

CURRENT LITERATURE

Denture Materials

By RALPH H. BOOS

A SUCCESSFUL denture base must meet more requirements, each to its highest degree, than any other plastic. It must be strong and adaptable, have accuracy and permanency of form and be lacking in absorptiveness. It must be easily kept clean and be entirely compatible with living tissue. It must be easy to manipulate and amenable to repair.

It must meet esthetic requirements; must be odorless and sensitive to thermal conductivity, and it must be reasonable in cost.

Today's newest material attempting to meet these requirements is acrylic resin.

"Acrylic" is a general term applicable to chemical substances derived from acrylic or methacrylic acids ranging from thick heavy liquids to glassy hard compounds.

Advanced technics require that prosthetic construction be classified and the processing be extended with a reduced temperature and a final treatment of boiling water or vulcanization, the end-result having finer physical properties. For denture processing, the monomer is mixed with the polymer to facilitate molding, and when heat is applied, the monomer goes through a reaction to form polymer and a homogeneous mass results. This material constitutes a valuable contribution, and although we expect and desire greater improvement, we can feel that dentistry has progressed greatly with the advent of acrylic resin.

Distribution of Alkaline Phosphatase in Normal and Inflamed Gingivae

By CHARLES FRANCOIS VALLOTTON

SINCE tissue metabolism is regulated to a great extent by enzymes, a study of the distribution of an enzyme, phosphatase, in healthy and pathologic gingivae may be of interest. The biochemical microtechnic devised by Takamatsu and independently by Gomori for the determination of the phosphatase enzyme in tissue sections was applied to specimens of gum tissue. One group of five patients presented clinically healthy gingivae and one group of eight patients presented clinically inflamed gingivae. The phosphatase reaction was positive in all specimens. Phosphatase was demonstrated in both the endothelium of capillaries and in the connective tissue. No phosphatase was to be found in the epithelial cells, contrary to previously reported findings obtained by another method. The absence of phosphatase in epithelial cells does not exclude *a priori* the theory of the phosphatase action in the precipitation and deposition of calculus. The writer suggests that the source of phosphatase may be in the bacteria rather than the epithelial cells of the gums. Serial sections showed that some capillaries were specifically stained throughout their entire length, whereas others were entirely free from any deposits. On comparing the phosphatase content of normal and pathologic gum tissue, it was found that, on the whole, phosphatase seems to be more consistently present and more clearly demonstrable in the endothelium of the inflamed tissues than in the normal tissues. This might be attributed to an increase, under irritation, of metabolic exchanges between serum and tissue or between serum and endothelium.—*Northwest. Univ. D. Res. & Grad. Study Bull.*, 42:8-11, April 1942.

Journal of Dental Research

Vol. 21, June 1942

***Utilization of Biologic principles in the Practice of Operative Dentistry II. Statistics, an Aid to Efficient Diagnosis. S. S. Arnim.—243.**

***Enamel of Shark's Teeth. Edmund Applebaum.—251.**

***Relationship of Dental Caries to Deficiencies of the Vitamin B Group. Albert H. Kniesner, Arvin W. Mann and Tom D. Spies.—259.**

***Acidogenic Properties of Certain Oral Micro-Organisms. H. J. Florestano.—263.**

***Titles marked with an asterisk are abstracted herewith.**

Effectiveness of Antibacterial Agents in Cavity Preparation. Samuel Seltzer.—269.
*Opsonin in Saliva. Carolyn W. Hammond and Joseph P. Weinmann.—279.
International Association for Dental Research. Proceedings of the Twentieth General Meeting, March 14-15, 1942. Hamilton B. G. Robinson, editor.—285.

Utilization of Biologic Principles in the Practice of Operative Dentistry. II. Statistics, an Aid to Efficient Diagnosis.—The purpose of this study is to present an analysis of certain statistical data that may be used to advantage by the dentist as a diagnostic aid during mouth examination. Charts illustrating cavity incidence on individual tooth surfaces of deciduous and permanent teeth are interpreted in terms applicable to clinical practice. The probability of caries occurrence on individual surfaces at varying ages is revealed. The relation of these probabilities to the location of lesions during mouth examination is exemplified.

Enamel of Shark's Teeth.—In sharks, there is an enamel organ formed from ectoderm, as in mammalian enamel formation. The ameloblasts are concerned in calcification of the matrix. In studying the teeth of sharks, the two tissues on the teeth, dentin and enamel, which are homologous with the tissues of other vertebrate teeth, are seen. Roentgenograms of shark teeth show that there is a marked difference of density of the two tissues, entirely comparable with that of the tissues in mammalian teeth. The direction of calcification of shark's enamel is somewhat like that of human enamel as described by Diamond and Weinmann and is correlated with the appearance of luster on the surface, which progresses from the tip of the tooth to its base. In a microscopic examination of a thin ground section, significant differences in the morphologic appearance of the two tissues and a sharp line of demarcation at the dentino-enamel junction due to difference in refractive index of the tissues are seen. In decalcified sections, the dentin matrix has numerous projections into the enamel, but the enamel matrix stains differently from the dentin matrix. The delicate strands projecting into the enamel matrix are definitely related to the dentin matrix, but this is also seen in marsupial enamel. The spindles of human enamel are vestigial. The evidence from paleontology indicates that shark's teeth are the forerunners of the teeth of modern vertebrates. Thus, from a consideration of all the evidence we conclude that the outer layer covering the teeth of the shark is a form of enamel.

Relationship of Dental Caries to Deficiencies of the Vitamin B Group.—A series of fifty-one patients between the ages of 4 and 20 years, inclusive, who came to the nutrition clinic of Hillman Hospital in Birmingham, Ala., with or without evidence of active clinical deficiency diseases of the vitamin B group were examined for dental caries. Clinical and roentgenographic examinations revealed no dental caries or restorations in eighteen patients (35.3 per cent). Forty-one patients with symptoms of recognizable deficiency diseases averaged 2.1 cavities. Ten patients without clinical symptoms of a dietary deficiency averaged 6.1 cavities, including ten restorations in two patients. The number of oral lactobacilli rose with the increased incidence of dental caries. Salivary pantothenic acid (a filtrate factor) values ranged from 0.012 to 0.19 micrograms per cubic centimeter of saliva. With the lactobacillus count as an index of caries activity, no significant difference was observed in the pantothenic acid content of the saliva from patients resistant or susceptible to dental caries. The fluorine concentration of the water used by these patients ranged from 0.027 to 0.097 parts per million.

Acidogenic Properties of Certain Oral Micro-Organisms.—Two hundred and forty-two cultures of oral aciduric micro-organisms were isolated from 237 individuals, 136 of which were carious and 101 non-carious. Tomato juice-agar (pH 5.0) was used for isolation of the various strains studied. Acidogenesis was determined through growth in dextrose-beef infusion broth (pH 6.6), the pH being measured by means of a glass electrode pH meter. Seventy-seven of 121 strains of the S form of lactobacilli produced a pH ranging from 4.0 to 3.6 after seven days' incubation. None of fourteen strains of the R form was capable of reducing the pH of broth below 5.25. Thirty-

nine of sixty-eight strains of streptococci produced a pH from 4.0 to 3.4. Of twenty-five strains of staphylococci, ten produced an acidity between pH 4.0 and 3.7. Acidogenic powers of oral yeast were slight. The lowest pH effected by any of fourteen strains was 5.17.

No correlation could be made between the absence or presence of caries and the amount of acid formed by micro-organisms isolated. Aciduric streptococci and staphylococci were isolated consistently from both carious and non-carious individuals. Their high acidogenic powers and presence in relatively large numbers in saliva suggest just as significant a rôle in caries as that of the lactobacillus.

Opsonin in Saliva.—The presence of a phagocytosis-stimulating factor in saliva was established by tests with the saliva of forty-one patients selected at random. Proof of the identity of this factor as opsonin was secured by absorption and heating experiments. It was possible also to reactivate the heated saliva. In addition, it was found that there may be a factor in saliva which reduces the ability of serum to initiate phagocytosis. The nature of this factor has not been determined.

Mineral Metabolisms of Healthy Adults on White and Brown Bread Dietaries

By R. A. McCance and W. M. Widdowson

The absorption and excretion of minerals in ten healthy adults, five men and five women, receiving 40-50 per cent of dietary calories in wheat flours of varying extraction and fortification with calcium, phosphorus and calciferol (vitamin D) were studied over a period of nine months. Calcium, phosphorus, magnesium and potassium were more completely absorbed when the diet was made up of 69 per cent flour than when made up with flour of 92 per cent extraction. Sodium phytate appeared to suppress the absorption of calcium and phosphorus, but not potassium. Of the phosphorus in the phytate, about 50 per cent was absorbed. The presence of vitamin D had no apparent effect on calcium absorption when the diet was made up with 92 per cent flour. Fortification of breads with calcium carbonate or phosphate improved the absorption of that element. White flour should contain 65 mg. of calcium carbonate per hundred grams. *J. Physiol.*, 101:44, June 2, 1942.

H. B. McCauley.

Ill Effects of Prolonged Recumbency in Paranasal Sinusitis

By E. C. Brown

Prolonged recumbency aggravates the symptoms of chronic sinusitis, notably puffiness and dark circles under the eyes, lymphadenitis, headaches, neuralgic pains, early morning hoarseness and cough. Untoward symptoms may develop from prolonged recumbency for two reasons: First, mucopurulent secretions are retained in the sinuses, with absorption of toxins through the sinus mucosa when these secretions are under pressure. Second, complications may result when organisms reaching the pharynx, and accumulating there, are maintained in intimate contact with the eustachian orifice.

Keeping the head high aids in drainage of infected sinuses and lessens the ill-effects of prolonged recumbency.—*Arch. Pediat.*, 59:546, August 1942.

Peter P. Dale.

Assimilation of Radioactive Phosphorus Following Phosphorus Deficiency in Rats

By W. E. Gaunt, H. D. Griffith and J. T. Irving

Rats maintained on a diet containing 0.12 per cent each of calcium and phosphorus retained less total phosphorus than those on a diet adequate in those elements. This reduction appeared almost entirely in the skeleton. Those deficient in calcium and phosphorus retained more than 90 per cent of an injected radiophosphorus dose ninety hours after administration, whereas normal rats retained less than 75 per cent of a similar dose in that time. The bulk of the radiophosphorus over 75 per cent retained by the deficient animals was found in muscle tissue. However, the skeletal tissues of those on an adequate diet retained more radiophosphorus than those of the deficiently maintained group. Retention by the teeth was about the same in the two groups; but, per unit weight, the bones and teeth of the

deficient animals retained 59 per cent and 27 per cent more radiophosphorus, respectively, than the same tissues of normal rats. The content of radiophosphorus in the teeth per gram was approximately half that of the bones in the normal groups, and about two-fifths of that of the skeleton of the deficient group.—*J. Physiol.*, 100:372, March 31, 1942.

H. B. McCAULEY.

A Case of Fourth Molars and Macrodontia

By J. STAZ

A CASE is recorded of an adult Bantu presenting macrodontia, maxillary fourth molars, supernumerary incisors and an abnormally large anteroposterior development of the maxilla. The mesiodistal diameter of the central incisors was 10.1 mm. and the diastema between them 9.8 mm. Two well-built, massive supernumerary teeth, resembling in size and form abnormal premolar teeth rather than incisors, erupted distally from the diastema. Measurements of the teeth and jaws of this case are compared with those taken of the Bantu by Shaw. The crown indices of the teeth in this case fall within the usual range found in the Bantu, while the crown nodules are found on the whole to be greater than the average.—*So. Afr. D. J.*, 16:200, June 1942.

PETER P. DALE.

Efficacy of the Use of Sulfathiazole in Dentistry

By J. D. GODWIN

QUANTITATIVE controlled studies by the marrow culture method indicate the usefulness and superiority of sulfathiazole as compared with sulfanilamide and sulfapyridine. Nature's attempt to wall off any infection and to set up a defense mechanism in order to prevent blood stream infection can best be helped by local applications of sulfathiazole at the site of infection and by maintaining a suitable blood level of the drug (5-8 mg.) with oral administration. For adults, the initial dose should be 2-4 gm., to be followed by 1-2 gm. every four hours day and night thereafter and to be continued as indicated. Toxic manifestations from oral administration may occur if blood levels recommended are maintained, probably owing to an idiosyncrasy rather than to the size of the dose.—*D. Items Int.*, 64:779, August 1942.

PETER P. DALE.

Removal of Unerupted Third Molar Extraorally

By J. W. MANSIE

A MAN, aged 45, apparently edentulous, complained of a foul discharge into his mouth originating from a sinus in the region of the lower left third molar. X-ray examination revealed that both lower third molars were unerupted. The right was relatively superficial, the left situated so deeply that the apices appeared to reach the angle of the mandible. A large area of bone destruction around the tooth joined the sinus. An occlusal film indicated that the tooth was close to the outer surface of the jaw. As it was too difficult to remove it intraorally, the external approach was employed. Under general anesthesia, and with aseptic precautions, an incision 1 inch long was made along the inferior border of the mandible. The soft tissues were arranged so that the opening was approximately above the tooth. A window was cut in the bone, the tooth removed and the cavity curetted. Clips were used to close the wound. Considerable swelling on the first day after the operation gradually subsided when drainage was established. Recovery was uneventful.—*Brit. D. J.*, 73:39, July 1942.

V. H. POWELL.

Rusting in Desalivated Albino Rats

By J. T. GINN and J. F. VOLKER

THE use of the desalivated albino rat in studying experimental dental caries has led to the observation that the salivary glands may have an endocrine function. Desalivated animals appear to be somewhat stunted in growth and show a marked rusting of the fur after from three to six weeks on a liquid diet of distilled water and irradiated evaporated milk fortified with copper, manganese and iron. These changes, which were especially pronounced in the female, tended to increase in intensity with age. A partial cure was obtained with daily injections of 40 micrograms of pantothenic acid (vitamin

B) and 20 mg. of choline. The experiments indicate that the rusting may have been the result of a disturbance of the normal relationship between the sex hormones and vitamin B factors caused by removal of the salivary glands.—*Endocrinology,* 31:282, August 1942.

H. B. McCAULEY.

An Investigation into the Connection Between the Vitamin C Content of the Blood and Periodontal Disease

By C. H. BLOCKLEY and P. E. BAENZIGER

CLINICAL and experimental data indicate that there is a definite relation between a low vitamin C blood level and certain periodontal diseases. The best method of saturating the tissues with vitamin C is administration of large doses of the synthetic form, 200-500 mg. daily. After the desired saturation is reached, a minimum of 0.5 mg. of ascorbic acid in natural or synthetic form should be given, to maintain a normal level. In the cases reported, marked improvement occurred after two or three weeks' therapy. A level of from 0.8 to 1.0 mg. per hundred cubic centimeters of blood will insure an adequate reserve of the vitamin in the tissues. Pyorrhea may be caused by a lack of vitamin C, but, for complete repair, treatment should be begun before pocket formation.—*Brit. D. J.,* 73:57, August 1, 1942.

V. H. POWELL.

Domestic Water and Dental Caries. V. Additional Studies of the Relation of Fluoride Domestic Waters to Dental Caries Experience in 4,425 White Children Aged 12 to 14 Years, of Thirteen Cities in Four States

By H. T. DEAN, F. A. ARNOLD, JR. and ELIAS ELVOVE

A COMPREHENSIVE clinical survey confirmed previous findings that the incidence of dental caries is in inverse ratio to the amount of fluorine contained in the water supply. The continuous use of domestic waters containing as low as one part per million was associated with a relatively low dental caries experience. Only sporadic instances of mild dental fluorosis were found, indicating that the caries inhibiting factors associated with fluorine are effective at concentrations so low that mottled enamel ceases to be an accessory complication. No relationship could be found between the caries incidence and the hours of sunshine, the hardness of the domestic water or gross dissimilarities in diet.—*Pub. Health Rep.,* 57:1155, August 1942.

R. J. HILDEBRAND.

Teeth in Fracture Line

By G. J. PARFITT, A. C. McLEOD and P. R. SHEPHERD

THE question of extracting teeth in the fracture line can be readily solved by considering the factors in the healing process. Teeth in the line of fracture should be removed in order to eliminate possibilities of infection, delayed union or non-union. However, if extraction exposes the fracture area to a greater risk of infection, the removal of the tooth should be postponed until some repair has occurred. If extraction is contemplated, immobilization of the parts should be effected before extraction in order to prevent loss of the blood clot.—*Brit. D. J.,* 73:35, July 1942.

A. PEARSON.

Effects of Hibernation on Tooth Development

By B. G. SARNAT and W. E. HOOK

THE effects of hibernation on tooth development in the thirteen-lived ground squirrel was studied in twenty-eight animals. Nine animals were used as controls. The animals were subjected to (1) notching of the incisors to determine the rates of attrition and eruption and (2) intravital staining with alizarin red in order to determine the rates of dentin apposition. The changes in body weight were observed during these experiments. No changes were found on gross or roentgenographic examination of the skulls, incisors, molars and femurs of animals subjected to hibernation. It was found that the weight loss was inversely proportional to the time the animal hibernated. The rate of attrition (and eruption) of the incisor was retarded in approximate proportion to the time the animal hibernated. The rate of dentin apposition of the incisor was likewise retarded in approximate proportion to the time the animal hibernated. Appro-

priate graphs and charts are furnished as to the exact recordings. The report demonstrates that all of the stages of tooth development, namely growth, calcification, eruption and attrition, are greatly retarded during hibernation. This is in accord with the marked depression of general metabolism in hibernation.—*Anat. Rec.,* 83:471, August 1942.

FRANK W. ARCHIBALD.

Enamel Organ of the Rat's Incisor Tooth in Vitamin E Deficiency

By J. T. IRVING

EXAMINATION was made of the incisor teeth of three female rats who had been on a vitamin E deficiency diet for 167 days from weaning. The animals were killed and longitudinal sections of the incisor teeth were stained with hematoxylin eosin.

The incisor teeth in the three vitamin E deficient diets showed a premature and abnormal degeneration of the enamel organ, in the center of the middle third of the tooth. In one rat, the epithelial papillae had disappeared and there was a shrinkage of the ameloblasts to an ill-arranged cubical layer. The other two rats showed a sudden disappearance of all layers of the enamel organ, which was replaced by fibrous tissue.

It would thus appear that rats on a diet adequate in all vitamins except vitamin E develop an atrophy of the enamel organ of a type unlike that caused by any other vitamin deficiency and possibly specific to vitamin E deficiency.—*Nature,* 150:122, July 25, 1942.

GLEN FOOR.

Effect of Therapeutic Blood Levels of Sulfanilamide and Sulfadiazine on Wound Healing

By H. A. ZINTEL, D. B. FRESHWATER, J. D. HARDY, W. M. HARRIS, C. S. NEER II and S. W. ROBINSON

THE extensive use of the sulfonamides to prevent and control infection in surgical wounds has raised the question of the effect that these drugs may have on wound healing. Mongrel dogs were selected as the experimental animals. Skin, fascia and stomach wall were experimentally wounded and indices of healing derived from histologic sections and the tensile strength of the wounds. An adequate intake of vitamin C was insured in all animals. Adequate therapeutic drug levels were maintained in the experimental group of animals by the administration of the sulfonamides directly into the stomach by means of a stomach tube. The authors have shown by means of numerous graphs and microscopic studies that no appreciable difference was found to exist between the experimental group and control group in regard to wound healing. It was concluded that therapeutic blood levels of sulfanilamide and sulfadiazine do not inhibit wound healing.—*Surgery,* 12:242, August 1942.

FRANK W. ARCHIBALD.

Action of Sulfonamides on the Respiration of Bacteria and Yeast

By M. G. SWAG, M. SHELBURNE and S. MUDD

THIS investigation of the inhibiting effects of sulfonamide drugs and their derivatives on the anaerobic decarboxylation of pyruvic acid by *Staphylococcus aureus, Eckerichia coli,* baker's and brewer's yeast and a carboxylase preparation from brewer's yeast offers support to the hypothesis that sulfonamides exert their bacteriostatic action through chemical affinity for the carrier proteins of certain respiratory enzymes of the bacterial cell. This affinity may in part be related to structural similarity between the components of the drugs and the corresponding respiratory coenzymes.—*J. Gen. Physiol.,* 25:805, July 1942.

R. J. HILDEBRAND.

Cost of Adequate Dental Care for Adults

By C. E. RUDOLPH

A GROUP of 485 adults whose average family income was slightly over $1,000 a year was studied. The type of care was adequate in quantity and quality, but consisted primarily of preventive and diagnostic service, plastic fillings, full and partial vulcanite dentures, palatal and lingual bars and a variety of supplementary services. Gold inlays, crowns, fixed and removable bridgework and more expensive denture materials were kept to a minimum. Two types of care were recognized, initial care and annual maintenance care. The initial bills ranged from less than $10.00 to $180.00 and averaged $52.66, while 50 per cent of the patients in-

curred bills of $45.00 or less. Relatively few of the patients incurred average annual maintenance bills of more than $20.00 a year, and figures under $10.00 were most frequent. The average maintenance care was $10.05 per year, while 50 per cent paid $8.30 or less. The data for each type of care were analyzed with respect to the individual service supplied, the cost to the clinic and the time spent in rendering the service. The various relationships are illustrated by attractive, well-constructed charts and graphs. —*J. Am. Col. Dentists*, 7:137, June 1942.

J. E. GILDA.

A Dental Cyst Associated with a Deciduous Tooth

By T. G. O'LOONEY

A GIRL, aged 12½ years, complained of a gradually increasing swelling on the left side of the lower jaw for four years. There was no pain. Examination revealed a second deciduous molar between the second premolar and the second permanent molar. The first permanent molar was missing. X-ray examination revealed a large cyst involving all three teeth and most of the bone. Under general anesthesia, the cyst and the three teeth were removed. A fragment of root at the base of the cyst cavity was found to be the distal root of the second deciduous molar. The bone was too thin to permit curettage, but the cavity was packed with gauze and treated. After a period of two and one-half years, the cyst cavity had filled with new bone.—*Brit. D. J.*, 73:65, August 1942.

V. H. POWELL.

The Blood Supply of Nerves

By W. E. ADAMS

THE first section of this article covers the anatomic evidence of a vasa nervorum, while a second part deals with the experimental evidence. There is special reference to the blood supply of the cranial nerves, especially in regard to the vagus and trigeminal nerves. The author concludes that without doubt all nerves receive a blood supply and that the various ganglia associated with peripheral nerves receive a much richer blood supply than that of the nerves themselves, although derived similarly from vessels in their vicinity. The cessation of the blood supply to any part of a nerve affects the passage of the nerve impulse and will ultimately induce a complete nerve block. Also, this mechanism is reversible. The restoration of the circulation through the nerve not only restores its capacity to conduct, but also initiates exaggerated responses, which may be interpreted as the subjective phenomenon of tingling. There is as yet no evidence that other subjective symptoms, such as pain and vertigo, may also result from ischemia of nerves.—*J. Anat.*, 76:323, July 1942.

FRANK W. ARCHIBALD.

Technic for Filling Root Canals

By J. O. HALL

A SIMPLE, positive method of filling root canals with a non-shrinkable, non-irritating, non-porous material in conjunction with guttapercha or metal points has been tested in practice six years with almost perfect results. Mixing of material is done in the canal itself, eliminating the trapping of air and the guesswork of past methods, also the soreness due to evaporation of chloroform through the apex. The materials used are: liquid eugenol or clove oil, two parts; phenol (crystal), one part; powder, white oxide of zinc (or oxyphosphate of zinc cements). The first combination is preferred because of ease of application. The manipulative technic is the same, except for time.

The patient is placed with the apex lower than the orifice of the dried canal, to utilize the force of gravity. The pulp chamber is filled with fluid. A file that will go to the apex (or bottom of the opened canal), fitting loosely to prevent jerking or perhaps breaking of the valve seal, is selected. The wet file is plunged into dry powder and carried into the canal to the apex, the operator working it upward and downward and mixing thoroughly in the canal. This procedure is carried out several times, the broach picking up more and more powder each time until a fairly stiff consistency is obtained. The excess fluid is absorbed from the chamber and dry powder is dusted in. The previously prepared point (guttapercha or metal) is placed firmly in position, and the canal is packed with extra guttapercha points until full. The case is checked immediately with the x-rays.—*Texas D. J.*, 60:337, September 1942.

ANNOUNCEMENTS

ANNOUNCEMENTS must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

CALENDAR OF MEETINGS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF ORAL DIAGNOSIS, Boston, Mass., November 12-13.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (DENTAL SUBSECTION), New York, December 28.

AMERICAN ASSOCIATION OF ORTHODONTISTS, Chicago, May 3-6, 1943.

AMERICAN DIETETIC ASSOCIATION, Detroit, Mich., October 19-22.

AMERICAN SOCIETY FOR THE ADVANCEMENT OF GENERAL ANESTHESIA IN DENTISTRY, New York, N. Y., October 26.

CHICAGO DENTAL SOCIETY, February 22-25, 1943.

DALLAS COUNTY (TEXAS) DENTAL SOCIETY MIDWINTER CLINIC, Dallas, January 25-27, 1943.

DISTRICT OF COLUMBIA DENTAL SOCIETY, second and fourth Tuesdays in each month, from October to June at the United States Public Health Service Auditorium, Washington.

GREATER NEW YORK DENTAL MEETING, New York, December 7-11.

NEW YORK SOCIETY FOR ORAL DIAGNOSIS, New York, October 21.

NEW YORK SOCIETY OF ORTHODONTISTS, New York, November 9-10.

ODONTOLOGICAL SOCIETY OF WESTERN PENNSYLVANIA, Pittsburgh, November 3-5.

PACIFIC COAST SOCIETY OF ORTHODONTISTS, San Francisco, Calif., February 22-24, 1943.

PAN AMERICAN ODONTOLOGICAL ASSOCIATION, New York, December 9.

STATE SOCIETIES

November

Florida, at Tampa (9-11)

Ohio, at Cincinnati (9-11)

February

Minnesota, at St. Paul (17-19)

STATE BOARDS OF DENTAL EXAMINERS

California, at San Francisco, February 15 and April 19, and at Los Angeles, March 22. Kenneth I. Nesbitt, 515 Van Ness Ave., San Francisco, Secretary.

Connecticut, at Hartford, November 17-21. Clarence G. Brooks, New London, Recorder.

New Jersey, April 4-9. Walter A. Wilson, 150 E. State St., Trenton, Secretary.

Ohio, at Columbus, October 19. Earl D. Lowry, 79 E. State St., Columbus, Secretary.

Virginia, at Richmond, March 30. John M. Hughes, 715 Medical Arts Bldg., Richmond, Secretary.

Wisconsin, at Milwaukee, October 5-9, Stephen F. Donovan, Tomah, Secretary.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE Dental Subsection of the American Association for the Advancement of Science will meet in New York December 28. The committee in charge of the meeting is composed of Arthur H. Merritt, William J. Gies and Paul C. Kitchin. There will be a symposium on "Dental Aspects of the Focal Infection Theory." Dentists and physicians are welcome.

PAUL C. KITCHIN, *Secretary,*
College of Dentistry,
Ohio State University,
Columbus.

AMERICAN ASSOCIATION OF ORTHODONTISTS

THE next meeting of the American Association of Orthodontists will be held at the Edgewater Beach Hotel, Chicago, May 3-6, 1943.

MAX E. ERNST, *Secretary,*
1250 Lowry Medical Arts Bldg.,
St. Paul, Minn.

AMERICAN DIETETIC ASSOCIATION

THE American Dietetic Association will hold its twenty-fifth annual meeting at the Hotel Statler, Detroit, Mich., October 19-22. All of the sessions of this meeting are planned to provide the dietitian with the greatest possible aid in playing her part under the difficult circumstances imposed by the war. Plans for increasing the number of trained dietitians available for Army service as well as for civilian service will be discussed. The best methods of teaching nutrition to the public and the most effective means whereby the dietetic profession can be of help to the Red Cross will be studied at this meeting. Ways of helping the dietitian to serve most effectively in hospitals, schools and industrial cafeterias will also be studied. Many key people in state and local groups are planning to attend this meeting. They are asked to bring their contributions for planning future action. It is also expected that they will take note of information available in prepared papers and round table discussions which they can disseminate to those dietitians in their local groups who are unable to attend.

AMERICAN SOCIETY FOR THE ADVANCEMENT OF GENERAL ANESTHESIA IN DENTISTRY

THE fall meeting of the American Society for the Advancement of General Anesthesia in Dentistry will be held October 26 at the Midston House, Thirty-Eighth St. and Madison Avenue, New York, at 8:30 p.m. The president, James R. Cameron, of Philadelphia, will preside. Adolph A. Walkling, associate professor of surgery, Jefferson Medical College, Philadelphia, will read a paper on anesthesia of choice in injuries and infections of the head and neck. Tracheotomy procedure will be demonstrated with lantern slides.

M. HILLEL FELDMAN, *Secretary,*
730 Fifth Ave.,
New York.

CHICAGO DENTAL SOCIETY MIDWINTER MEETING

THE 1943 Midwinter Meeting of the Chicago Dental Society will be held at the Palmer House, February 22-25.

HAROLD W. OPPICE, *Secretary.*

DALLAS COUNTY DENTAL SOCIETY MIDWINTER CLINIC

THE sixteenth annual midwinter dental clinic sponsored by the Dallas County (Texas) Dental Society will be held at the Hotel Adolphus, Dallas, January 25-27, 1943. Three nationally known clinicians will be presented in a three-day study course. The fee of $15 includes the banquet and table clinics, January 26. Members of the American Dental Association are invited.

PHELPS J. MURPHEY, *Chairman,*
Publicity Committee,
Fairmount at Welborn,
Dallas.

GREATER NEW YORK DENTAL MEETING

THE next Greater New York Dental Meeting will be held in the Hotel Pennsylvania, New York, December 7-11.

WALTER A. QUINN, *Chairman,*
Press and Publication.

NEW YORK SOCIETY FOR ORAL DIAGNOSIS

THE next meeting of the New York Society for Oral Diagnosis will be held in Squibb Hall, 745 Fifth Ave., New York, October 21, at 9:30 p.m. The subject of the evening will be "Accurate Diagnosis Preceding Treatment of Wartime Injuries of the Face and Jaws." Morris I. Schamberg, M.D., D.D.S., will address the society. Members of the medical and dental professions are invited.

H. JUSTIN ROSS, *Secretary,*
515 Madison Ave.,
New York.

NEW YORK SOCIETY OF ORTHODONTISTS

THE next meeting of the New York Society of Orthodontists will be held at the Waldorf-Astoria Hotel, New York, November 9-10.

NORMAN L. HILLYER, *Secretary,*
Professional Bldg.,
Hempstead.

ODONTOLOGICAL SOCIETY OF WESTERN PENNSYLVANIA

THE Odontological Society of Western Pennsylvania will hold its sixty-first annual fall meeting November 3-5 in the William Penn Hotel, Pittsburgh.

M. H. SMITH, *Office Secretary.*

PACIFIC COAST SOCIETY OF ORTHODONTISTS

THE next meeting of the Pacific Coast Society of Orthodontists will be held in San Francisco February 22-24, 1943.

EARL F. LUSSIER, *Secretary,*
450 Sutter Bldg.,
San Francisco.

PAN AMERICAN ODONTOLOGICAL ASSOCIATION

THE next annual dinner meeting of the Pan American Odontological Association will be held in the Hotel Pennsylvania, New York, December 9, at 6 o'clock.

RALPH HOWARD BRODSKY,
Executive Secretary,
14 E. 81st St.,
New York.

FLORIDA STATE DENTAL SOCIETY

THE next annual meeting of the Florida State Dental Society will be held at Tampa, November 9-11.

W. P. WOOD, JR., *Secretary,*
442 W. Lafayette St.,
Tampa.

MINNESOTA STATE DENTAL ASSOCIATION

THE sixtieth annual meeting of the Minnesota State Dental Association will be held in the Municipal Auditorium, Minneapolis, February 17-19, 1943.

L. M. CRUTTENDEN, *Secretary,*
498 Lowry Bldg.,
St. Paul.

OHIO STATE DENTAL SOCIETY

THE next annual meeting of the Ohio State Dental Society will be held at the Netherland-Plaza Hotel, Cincinnati, November 9-11.

EDWARD C. MILLS, *Secretary,*
255 E. Broad St.,
Columbus.

BOARD OF DENTAL EXAMINERS OF CALIFORNIA

THE next examinations to be conducted by the Board of Dental Examiners of California for a license to practice dentistry and for a license to practice dental hygiene in California will be held in San Francisco, commencing on February 15, 1943, in Los Angeles, commencing on March 22, 1943, and again in San Francisco commencing on April 19, 1943. All credentials must be in the office of the Secretary, Room 203, 515 Van Ness Avenue, San Francisco, at least twenty days prior to the date of the examinations. Address all communications to Kenneth I. Nesbitt, Secretary, Room 203, 515 Van Ness Avenue, San Francisco.

CONNECTICUT DENTAL COMMISSION

THE Connecticut Dental Commission will meet in Hartford, November 17-21, for the examination of applicants for license to practice dentistry and dental hygiene and to transact any other business proper to come before it. Applications should be in the hands of the recorder at least ten days before the meeting. For application blanks and further information, apply to Clarence G. Brooks, Recorder, New London.

NEW JERSEY STATE BOARD OF REGISTRATION AND EXAMINATION IN DENTISTRY

THE State Board of Registration and Examination in Dentistry in New Jersey will hold its next examination commencing April 4, 1943 and continuing for five days. Upon application to the secretary, a copy of the requirements and rules, instruction sheet and preliminary application will be sent. Any person desiring to apply as a candidate must file the preliminary application blank, together with the examination fee of $25, on or before February 15.

WALTER A. WILSON, *Secretary,*
150 E. State St.,
Trenton.

OHIO STATE DENTAL BOARD

THE October Examination of the Ohio State Dental Board will be held at Ohio State University College of Dentistry, Columbus, the week beginning October 19. All applications must be in the hands of the secretary at least ten days before the examination. For further information, apply to Earl D. Lowry, Secretary, 79 E. State St., Columbus.

VIRGINIA STATE BOARD OF DENTAL EXAMINERS

THE next regular meeting of the Virginia State Board of Dental Examiners will be held at the Medical College of Virginia, Richmond, beginning at 9 a.m., March 30, 1943. Each applicant will be required to present a certificate from the Virginia State Board of Education, State Office Building, Richmond, showing that he has had at least one

year of academic education equal to one year of college work. He must be a graduate of a Class A dental college and must be prepared to do any kind of practical or operative work necessary to the general practice of dentistry. The theoretical examination covers subjects usually found in a complete dental curriculum. Incomplete applications will be returned. No applications will be accepted after March 20. For application blanks and further information, apply to

JOHN M. HUGHES, *Secretary,*
715 Medical Arts Bldg.,
Richmond.

STATE OF WISCONSIN BOARD OF DENTAL EXAMINERS

THE State of Wisconsin Board of Examiners will hold its next examination at Marquette Dental School, Milwaukee, October 5-9. Examinations will be given for licensure of dentists and hygienists. All applications must be in by September 29. For application blanks and information, address

STEPHEN F. DONOVAN, *Secretary,*
Tomah.

DENTAL RESIDENCY

THE University of Oregon Medical School Hospitals and Clinics offers a residency in dental medicine and oral surgery, the period of service to be one year, with compensation $40 monthly, in addition to board, room and laundry. The division is under the general direction of the department of medicine and the direct supervision of the head of the division and a visiting staff of sixteen dentists. Service is carried on in the outpatient clinic and the three hospitals. Application blanks will be furnished on request. Direct inquiries to

RICHARD B. DILLEHUNT, *Dean,*
University of Oregon Medical School,
Portland.

CARNEGIE FELLOWSHIPS FOR RESEARCH AND GRADUATE WORK IN THE DENTAL SCIENCES

AIDED by the Carnegie Corporation of the New York and the Eastman Dental Clinic, the School of Medicine and Dentistry of the University of Rochester offers scholarships paying $1,200-$1,800 per annum to well-trained dental graduates who are interested in research or who desire special training in the basic medical sciences as an aid to dental teaching or practice. A few fellowships also offer part-time training in oral surgery. On appointment, the applicant is given the title of Fellow in Dentistry and, according to his interest, works as a graduate student in one of the departments of the medical schools. Here, excellent laboratory facilities, adequate direction and close contact with various investigations related to medicine and dentistry help his research and study. Fellows are encouraged to attend medical classes, seminars and staff meetings and, when opportunity presents itself, to participate in class instruction and scientific meetings. Contact with the problems of clinical dentistry may be maintained through the Oral Surgery Clinic of the Strong Memorial Hospital and the Rochester Dental Dispensary. With the approval of the Graduate Council of the university, Fellows may prepare themselves for the degree of M.S. or Ph.D. Applications should be made to

GEORGE H. WHIPPLE, *Dean,*
School of Medicine and Dentistry,
Rochester, N. Y.

NEW YORK UNIVERSITY COLLEGE OF DENTISTRY POSTGRADUATE COURSE

THE New York University of Dentistry announces a postgraduate course in inhalation anesthesia, with special emphasis on nitrous oxide-oxygen anesthesia, conducted by E. A. Rovenstine, professor of anesthesia, N. Y. U. College of Medicine and Bellevue Hospital, and A. S. Mecca, assistant professor of oral surgery, N. Y. U. College of Dentistry and Bellevue Hospital. The course will be given on Friday mornings October 2 to November 6 inclusive. Direct all communications to the office of the dean, N. Y. U. Dental College, 209 E. 23rd St., New York, N. Y.

COLUMBIA UNIVERSITY SCHOOL OF DENTAL AND ORAL SURGERY REFRESHER COURSES

COLUMBIA University School of Dental and Oral Surgery offers a short course in periodontia for qualified graduates in dentistry September 18, 1942, to January 15, 1943.

A ten-day intensive course will include lectures, discussions, demonstrations and clinical practice. An extended course, one half day per week for two sessions, will include lectures, discussions and supervised technical treatment. Both courses will be

conducted by Frank E. Beube, Isador Hirshfeld, Harold J. Leonard (executive officer) and Arthur H. Merritt.

The courses given at the School of Dental and Oral Surgery, Columbia University, are designed to be "refresher" courses; i.e., to bring practitioners abreast of modern undergraduate teaching in theory and practice in the subject. Admission to the course is limited to qualified graduates in dentistry who are members in good standing of the American Dental Association or recognized sectional organizations. In the case of foreign applicants, membership in the applicant's national dental organization is required.

Information can be obtained from the registrar, School of Dental and Oral Surgery, 630 West 168th Street, New York, N. Y.

THE MOUNT SINAI HOSPITAL NEW YORK CITY TWELFTH LECTURE COURSE IN DENTAL MEDICINE SEASON OF 1942-1943

October 20; Solon S. Bernstein: New Concepts of Dental Infection and Systemic Disease.

November 17; Harry A. Goldberg: Prostatitis and Multiple Arthritis of Dental Origin Discussed by William H. Mencher, M.D.

December 15: Presentation of cases by the medical and dental staff.

January 19; Jerome H. Kohn: Care of the Child, with Special Reference to Dentition and Nutrition.

February 16; Emanuel Schoenbach: Bacteriology, with Special Reference to Dental-Medical Problems.

March 16; Bernard Sussman: Superior and Inferior Impression Technic as Developed in the Mount Sinai Hospital Dental Department.

April 20; Presentation of cases by the dental staff.

All lectures will start promptly at 8:30 p.m. and will be held in the lecture room on the third floor of the Administration Building. There will be a presentation of clinical cases before each lecture. All physicians and dentists are invited.

HARRY A. GOLDBERG,
Attending Dentist.

UNITED STATES PATENTS APPLICABLE OR PERTAINING TO DENTISTRY ISSUED DURING JULY 1942

July 7

No. 2,288,736, HAROLD A. OSSERMAN. Composition for assuring conformity of molding composition to wax patterns.

July 14

No. 2,289,625, JOSEPH E. BURNS. Dental floss holder.

July 21

No. 2,290,357, ADOLPH RICKENBACHER. Toothbrush.

No. 2,290,454, LEON JOSEF STEINBERG. Mechanical toothbrush.

No. 2,290,482, EWELL NEIL. Instrument for making measurements.

No. 2,290,672, JACOB J. CANTOR. Surgical chair.

July 28

No. 2,290,894, FELIX RIVANOV. Toothbrush.